CHANGE

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

8260.3B CHG 17

2/13/98

ARMY .... TM 95-226
....
USAF ....
USCG ....

SUBJ: UNITED STATES STANDARD FOR TERMINAL INSTRUMENT PROCEDURES (TERPS)

1. PURPOSE. This change incorporates criteria contained in AVN Supplements to TERPS. It also corrects and updates criteria for evaluating the visual portion of an instrument approach, computing descent gradient, descent angle, and Visual Descent Point (VDP). Area navigation (RNAV) criteria are updated.

2. DISTRIBUTION. This change is distributed in Washington Headquarters to the division level of Flight Standards Service; Air Traffic Service; the Offices of Airport Safety and Standards; and Communications, Navigation, and Surveillance Systems; to the National Flight Procedures Office; the Regulatory Standards and Compliance Division at the Mike Monroney Aeronautical Center; to the regional Flight Standards divisions; and to special Military and Public Addressees.

3. CANCELLATION. Order 8260.34, Glide Slope Threshold Crossing Height Requirements, dated 10/26/83, is canceled. This change also incorporates the criteria contained in VN Supplements 2 and 3 to Order 8260.3; therefore, VN SUP 2, dated 10/8/92, and VN SUP 3, dated 1/11/93, are canceled.

4. EFFECTIVE DATE. April 20, 1998**.**

5. EXPLANATION OF CHANGES. This change incorporates all AVN Supplements to TERPS, provides a method for evaluating the visual portion of an instrument approach, and introduces criteria for determining final segment length based on descent angle. It revises ILS and PAR obstacle clearance calculations; adds criteria contained in FAA Order 8260.34, Glide Slope Threshold Crossing Height Requirements, to chapter 9; and updates chapter 15.

6. DISPOSITION OF TRANSMITTAL. After filing, this change transmittal should be retained.

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CHAPTER 1. ADMINISTRATIVE

SECTION 1. SCOPE

1. PURPOSE. This handbook contains criteria which shall be used to formulate, review, approve, and publish procedures for instrument approach and departure of aircraft to and from civil and military airports. These criteria are for application at any location over which an appropriate United States agency exercises jurisdiction.

2. DISTRIBUTION. This order is distributed to selected Federal Aviation Administration (FAA) addressees. For distribution within the Department of Defense, see pages v and vi.

3. CANCELLATION. Order 8260.34, Glide Slope Threshold Crossing Height Requirements, dated 10/26/83, is canceled. This change also incorporates the criteria contained in VN Supplements 2 and 3 to Order 8260.3B; therefore, VN SUP 2, dated 10/8/92, and VN SUP 3, dated 1/11/93, are canceled.

4. EXISTING PROCEDURES. Existing procedures shall comply with these standards. Approval of nonstandard procedures as required is specified in paragraph 141.

5. TYPES OF PROCEDURES. Criteria are provided for the following types of authorized instrument procedures:

a. Precision Approach.

(1) Straight-In. A descent in an approved procedure where the navigation facility alignment is normally on the runway centerline and glide slope (GS) information is provided. For example, Precision Approach Radar (PAR), Instrument Landing System (ILS) and Microwave Landing System (MLS) procedures are precision approaches.

(2) Simultaneous. A procedure which provides for approaches to parallel runways. This procedure uses two or more ILS-equipped parallel runways. Simultaneous approaches, when authorized, shall be radar monitored. Military commanders may approve simultaneous approaches based upon dual precision radar.

b. Nonprecision Approach.

(1) Straight-In. A descent in an approved procedure in which the final approach course (FAC) alignment and descent gradient permits authorization of straight-in landing minimums.

(2) Circling. A descent to circling minimums from which a circle to land maneuver is performed, or an approach procedure which does not meet criteria for authorizing straight-in landing minimums.

c. Departure Procedures. Procedures designed to provide obstacle clearance during instrument departures.

6. WORD MEANINGS. Word meanings as used in this manual:

a. Shall means that application of the criteria is mandatory.

b. Should means that application of the criteria is recommended.

c. May means that application of the criteria is optional.

7.-119. RESERVED.

SECTION 2. ELIGIBILITY, APPROVAL, AND RETENTION

120. ELIGIBILITY.

a. Military Airports. Procedures at military airports shall be established as required by the commander under the directives of the appropriate military service.

b. Civil Airports. Instrument procedures shall be provided at civil airports open to the aviation public whenever a reasonable need is shown. No minimum number of potential instrument approaches is specified; however, the responsible FAA office must determine that a public procedure will be beneficial to more than a single user or interest. Private procedures, for the exclusive use of a single interest, may be provided on a reimbursable basis under Title 14 of the Code of Federal Regulations (14 CFR) part 171 where applicable, if they do not unduly conflict with the public use of airspace. Reasonable need is deemed to exist when the instrument flight procedure will be used by:

(1) A certificated air carrier, air taxi, or commercial operator; or

(2) Two or more aircraft operators whose activities are directly related to the commerce of the community; or

(3) Military aircraft.

121. REQUESTS FOR PROCEDURES. Requests for military procedures are processed as described by the appropriate military service. No special form is required for requesting civil procedures. Civil requests may be made by letter to the appropriate Regional Office. Requests for civil procedures shall be accepted from any aviation source, provided the request shows that the airport owner/operator has been advised of this request. (This advice is necessary only when the request is for an original procedure to an airport not already served by an approach procedure.) Airport owners/operators will be advised of additional requests for procedures by the FAA as soon as possible after receipt thereof.

122. APPROVAL. Where a military requirement or reasonable civil need has been established, a request for an instrument approach procedure (IAP) and/or instrument departure procedure for an airport shall be approved if the following minimum standards are met:

a. Airport. The airport landing surfaces must be adequate to accommodate the aircraft which can be reasonably expected to use the procedure. Appropriate runway markings, and runway holding position markings and signs, shall be established and in place. See AC 150/5340-1, Marking of Paved Areas on Airports, or appropriate military directives as applicable. Runway lighting is required for approval of night instrument operations. EXCEPTION: Do NOT deny takeoff and departure procedures at night due solely to the absence of runway edge lights. The airport must have been found acceptable for instrument flight rules (IFR) operations as a result of an airport airspace analysis conducted pursuant to FAA Handbook 7400.2, Procedures for Handling Airspace Matters, and/or appropriate military directives, as applicable. Only circling minimums shall be approved to airports where the runways are not clearly defined.

b. Navigation Facility. All electronic and visual navigation facilities used must successfully pass flight inspection.

c. Obstacle Marking and Lighting. Obstacles which penetrate 14 CFR part 77 imaginary surfaces are obstructions and, therefore, should be marked and lighted, insofar as is reasonably possible under FAA Advisory Circular AC 70/7460.1, Obstruction Marking and Lighting. Those penetrating the 14 CFR part 77 approach and transitional surfaces should be removed or made conspicuous under that AC. Normally, objects which are shielded need not be removed or made conspicuous.

***NOTE:** In military procedures, the appropriate military directives apply.*

d. Weather Information. Terminal weather observation and reporting facilities must be available for the airport to serve as an alternate airport. Destination minimums may be approved when a general area weather report is available prior to commencing the approach and approved altimeter settings are available to the pilot prior to and during the approach consistent with communications capability.

e. Communications. Air-to-ground communications must be available at the initial approach fix (IAF) minimum altitude and when the aircraft executing the missed approach reaches the missed approach altitude. At lower altitudes, communications shall be required where essential to the safe and efficient use of airspace. Air-to-ground communication normally consists of ultra high frequency (UHF) or very high frequency (VHF) radio, but high frequency (HF) communication may be approved at locations which have a special need and capability. Other suitable means of point-to-point communication, such as commercial telephone, are also required to file and close flight plans.

123. RETENTION AND CANCELLATION. Civil instrument procedures shall be canceled when a re-evaluation of the usefulness of an IAP indicates that the benefits derived are not commensurate with the costs of retaining the procedure. This determination will be based upon an individual evaluation of requirements peculiar to each specific location, and will consider airport complexity, military requirements, planned airport expansion, and the need for a backup or supplement to the primary instrument approach system. Certain special procedures exist, generally based on privately operated navigation facilities. When a procedure based on a public facility is published, special procedures for that airport shall be canceled unless retention provides an operational advantage to the user. Before an instrument procedure is canceled, coordination with civil and military users shall be effected. Care shall be taken not to cancel procedures required by the military or required by air carrier operators at provisional or alternate airports. Military procedures shall be retained or canceled as required by the appropriate military authority.

124.-129. RESERVED.

SECTION 3. RESPONSIBILITY AND JURISDICTION

130. RESPONSIBILITY.

a. Military Airports. The United States Army, Navy, Air Force, and Coast Guard shall establish and approve instrument procedures for airports under their respective jurisdictions. The FAA will accept responsibility for the development and/or publication of military procedures when requested to do so by the appropriate military service through an interagency agreement. Military instrument procedures are official procedures. The FAA (AVN-100 Regional FPO) shall be informed when military procedures are canceled.

b. Civil Airports. The FAA shall establish and approve instrument procedures for civil airports.

c. Military Procedures at Civil Airports. Where existing FAA approach or departure procedures at civil airports do not suffice, the military shall request the FAA to develop procedures to meet military requirements. These requirements may be met by modification of an existing FAA procedure or development of a new procedure. The FAA shall formulate, coordinate with the military and industry, and publish and maintain such procedures. The military shall inform the FAA when such procedures are no longer required.

131. JURISDICTION. The United States Army, Navy, Air Force, and Coast Guard Commanding Officers, or FAA Regional Directors having jurisdiction over airports are responsible for initiating action under these criteria to establish or revise TERPS when a reasonable need is identified, or where:

a. New facilities are installed.

b. Changes to existing facilities necessitate a change to an approved procedure.

c. Additional procedures are necessary.

d. New obstacles or operational uses require a revision to the existing procedure.

132.-139. RESERVED.

SECTION 4. ESTABLISHMENT

140. FORMULATION. Proposed procedures shall be prepared under the applicable portion of this publication as determined by the type and location of navigation facility and procedure to be used. To permit use by aircraft with limited navigational equipment, the complete procedure should be formulated on the basis of a single navigation facility whenever possible. However, the use of an additional facility of the same or different type in the procedure to gain an operational advantage is permitted.

141. NONSTANDARD PROCEDURES. The standards contained in this manual are based on reasonable assessment of the factors which contribute to errors in aircraft navigation and maneuvering. They are designed primarily to assure that safe flight operations for all users result from their application. The dimensions of the obstacle clearance areas are influenced by the need to provide for a smooth, simply computed progression to and from the en route system. Every effort shall be made to formulate procedures in accordance with these standards; however, peculiarities of terrain, navigation information, obstacles, or traffic congestion may require special consideration where justified by operational requirements. In such cases, nonstandard procedures which deviate from these criteria may be approved, provided they are fully documented and an equivalent level of safety exists. A nonstandard procedure is not a substandard procedure, but is one which has been approved after special study of the local problems has demonstrated that no derogation of safety is involved. The FAA, Technical Programs Division (AFS-400), is the approving authority for nonstandard civil procedures. Military procedures which deviate from standards because of operational necessity, and in which an equivalent level of safety is not achieved, shall include a cautionary note to identify the hazard and shall be marked "not for civil use."

142. CHANGES. Changes in instrument procedures shall be prepared and forwarded for approval in the same manner as in the case of new procedures. Changes so processed will not be made solely to include minor corrections necessitated by changes in facility frequencies, variation changes, etc., or by other minor changes not affecting the actual instrument procedure. Changes which require reprocessing are those which affect fix, course, altitude, or published minimums.

143.-149. RESERVED.

SECTION 5. COORDINATION

150. COORDINATION. It is necessary to coordinate instrument procedures to protect the rights of all users of airspace.

a. Military Airports. All instrument procedures established or revised by military activities for military airports shall be coordinated with the FAA or appropriate agency or an overseas host nation. When a procedure may conflict with other military or civil activities, the procedure shall also be coordinated with those activities.

b. Civil Airports. Prior to establishing or revising instrument procedures for civil airports, the FAA shall, as required, coordinate such procedures with the appropriate civil aviation organizations. Coordination with military activities is required when a military operating unit is based at the airport or when the proximity of a military airport may cause procedures conflicts.

c. Air Traffic Control (ATC). Prior to establishing or revising instrument procedures for a military or civil airport, the initiating office shall coordinate with the appropriate FAA Air Traffic office to ensure compatibility with air traffic flow and to assess the impact of the proposed procedure on current or future air traffic programs.

d. Airspace Actions. Where action to designate controlled airspace for a procedure is planned, the airspace action should be initiated sufficiently in advance so that effective dates of the procedure and the airspace action will coincide.

e. Notice to Airmen (NOTAM). A NOTAM to **RAISE** minimums may be issued in case of emergencies; i.e., facility outages, facility out-of tolerance conditions, new construction which penetrates critical surfaces, etc. NOTAM's may also be issued to **LOWER** minimums when a supporting facility is added and a significant change in minimums (60 feet in MDA/DH or a reduction in visibility) will result. A NOTAM may be issued to **RAISE OR LOWER** minimums as appropriate on a no-FAF procedure when a procedure turn (PT) altitude is modified as the result of construction or terrain, or when a facility restriction is removed. However, a complete new procedure may not be issued by NOTAM, except where military requirements dictate. ATC shall be advised of the required NOTAM action prior to issuance and normal coordination shall be effected as soon as practicable.

151. COORDINATION CONFLICTS. In areas under the FAA jurisdiction, coordination conflicts which cannot be resolved at the field level shall be submitted to the appropriate FAA region for additional coordination and resolution. Problems which are unresolved at the regional level shall be forwarded to the FAA, AFS-400, for action. If the problem involves a military procedure, parallel action through military channels shall be taken to expedite coordination at the appropriate level.

152.-159. RESERVED.

SECTION 6. IDENTIFICATION OF PROCEDURES

160. IDENTIFICATION OF PROCEDURES. Instrument procedures shall be identified to be meaningful to the pilot, and to permit ready identification in ATC phraseology.

161. STRAIGHT-IN PROCEDURE IDENTIFICATION. Instrument procedures which meet criteria for authorization of straight-in landing minima shall be identified by a prefix describing the navigational system providing the final approach guidance and the runway to which the FAC is aligned:

a. Non-RNAV. ILS runway (Rwy) 18R, localizer (LOC) back course (BC) Rwy 7, Tactical Air Navigational Aid (TACAN) Rwy 36, localizer type directional aid (LDA) Rwy 4, nondirectional radio beacon (NDB) Rwy 21, VHF omni-directional radio range (VOR) Rwy 15, VOR/distance measuring equipment (DME) Rwy 6, ILS or TACAN Rwy 9, etc. A slash (/) shall indicate that more than one type of equipment must be used to execute the final approach; e.g., VOR/DME, etc. (The designation DME/RADAR on the profile view of a procedure indicates ATC RADAR is available to identify the fix when DME cannot be used. In this case, DME is **NOT** part of the procedure name). When procedures are combined, the word 'or' shall indicate either type of equipment may be used to execute the final approach; e.g., ILS or TACAN, ILS or NDB, VOR/DME or TACAN, etc. When multiple approaches using the same final approach guidance are developed to the same runway, all subsequent approaches after the first procedure developed for that runway/navigational aid combination shall be identified with a pronounceable name. Examples are: BAY ILS/DME RWY 28L, GLACIER LDA/DME RWY 8.

b. RNAV. VOR/DME RNAV Rwy 20, FMS RNAV Rwy 26.

c. GPS. GPS procedures are identified by the term GPS only; e.g., GPS Rwy 15.

162. CIRCLING PROCEDURE IDENTIFICATION. When a procedure does not meet criteria for straight-in landing minimums authorization, it shall be identified by the type of navigational aid (NAVAID) which provides final approach guidance, and an alphabetical suffix. The first procedure formulated shall bear the suffix "A" even though there may be no intention to formulate additional procedures. If additional procedures are formulated, they shall be identified alphabetically in sequence, e.g., VOR-A, VOR/DME-B, NDB-C, NDB-D, LDA-E, GPS-A, etc. A revised procedure will bear its original identification.

163. DIFFERENTIATION. Where high altitude procedures are required, the procedure identification shall be prefixed with the letters "HI" e.g., HI-VOR Rwy 5.

164.-169. RESERVED.

SECTION 7. PUBLICATION

170. SUBMISSION. Instrument procedures shall be submitted by the approving authority on forms provided by the originating agency. A record of coordination shall be maintained by the originating agency. Procedures shall be routed under current orders or directives of the originating agency.

171. ISSUANCE. The following are designated as responsible offices for the release of approved instrument procedures for each agency.

a. Army. Director, U.S. Army Aeronautical Services Agency.

b. Navy and Marine Corps. Chief of Naval Operations (CNO), Naval Flight Information Group.

c. Air Force. Headquarters, Air Force Flight Standards Agency, Instrument Standards Division.

d. Coast Guard. Commandant, U.S. Coast Guard.

e. Civil. Administrator, FAA.

172. EFFECTIVE DATE. TERPS and revisions thereto shall be processed in sufficient time to permit publication and distribution in advance of the effective date. Effective dates should normally coincide with scheduled airspace changes except when safety or operational effectiveness is jeopardized. In case of emergency, or when operational effectiveness dictates, approved procedures may be disseminated by NOTAM (see paragraph 150e). Procedures disseminated by NOTAM must also be processed promptly in the normal fashion and published in appropriate instrument procedures charts and in the Federal Register when required.

173.-199. RESERVED.

CHAPTER 2. GENERAL CRITERIA

200. SCOPE. This chapter contains only that information common to all types of TERPS. Criteria which do not have general application are located in the individual chapters concerned with the specific types of facilities.

201.-209. RESERVED.

SECTION 1. COMMON INFORMATION

210. UNITS OF MEASUREMENT. Units of measurement shall be expressed as set forth below:

a. Bearings, Courses, and Radials. Bearings and courses shall be expressed in degrees magnetic. Radials shall also be expressed in degrees magnetic, and shall further be identified as radials by prefixing the letter "R" to the magnetic bearing FROM the facility. For example, R-027 or R-010.

b. Altitudes. The unit of measure for altitude in this publication is feet. Published heights below the transition level (18,000 feet) shall be expressed in feet above mean sea level (MSL); e.g. 17,900 feet. Published heights at and above the transition level (18,000 feet) shall be expressed as flight levels (FL); e.g., FL 180, FL 190, etc. Reference Title 14 of the Code of Federal Regulations (14 CFR) part 91.81, FAA Order 7110.65, Air Traffic Control, paragraph 85.

c. Distances. Develop all distances in nautical miles (NM) (6076.11548 feet or 1852 meters per NM) and hundredths thereof, except where feet are required. Use the following formulas for feet and meter conversions:

$$feet = \frac{meters}{0.3048} \qquad meters = feet \times 0.3048$$

When applied to visibilities, distances shall be expressed in statute miles (5280 feet per SM) and the appropriate fractions thereof. Expression of visibility values in NM is permitted in overseas areas where it coincides with the host nation practice. Runway visual range (RVR) shall be expressed in feet.

d. Speeds. Aircraft speeds shall be expressed in knots initiated airspeed (KIAS).

e. Determination of Correctness of Distance and Bearing Information. The approving agency is the authority for correctness of distance and bearing information, except that within the United States, its territories, and possessions, the National Oceanic and Atmospheric Administration is the authority for measurements between all civil navigation aids and between those facilities incorporated as part of the National Airspace System (NAS).

211. POSITIVE COURSE GUIDANCE (PCG). PCG shall be provided for feeder routes, initial (except as provided for in paragraph 233b), intermediate, and final approach segments. The segments of a procedure wherein PCG is provided should be within the service volume of the facility(ies) used, except where Expanded Service Volume (ESV) has been authorized. PCG may be provided by one or more of the navigation systems for which criteria has been published herein.

212. APPROACH CATEGORIES (CAT). Aircraft performance differences have an effect on the airspace and visibility needed to perform certain maneuvers. Because of these differences, aircraft manufacturer/ operational directives assign an alphabetical category to each aircraft so that the appropriate obstacle clearance areas and landing and departure minimums can be established in accordance with the criteria in this manual. The categories used and referenced throughout this manual are: CAT A, B, C, D, and/or E. Aircraft categories are defined in 14 CFR part 97.

213. APPROACH CATEGORY APPLICATION. The approach category operating characteristics shall be used to determine turning radii minimums and obstacle clearance areas for circling and missed approach.

214. PROCEDURE CONSTRUCTION. An IAP may have four separate segments. They are the initial, the intermediate, the final, and the missed approach segments. In addition, an area for circling the airport under visual conditions shall be considered. An approach segment begins and ends at the plotted position of the fix; however, under some circumstances certain segments may begin at specified points where no fixes are available. The fixes are named to coincide with the associated segment. For example, the intermediate segment begins at the intermediate fix (IF) and ends at the final approach fix (FAF). The order in which this chapter discusses the segments is the same order in which the pilot would fly them in a completed procedure; that is from an initial, through an intermediate, to a final approach. In constructing the procedure, the FAC should be identified first because it is the least flexible and most critical of all the segments. When the final approach has been determined, the other segments should be blended with it to produce an orderly maneuvering pattern which is responsive to the local traffic flow. Consideration shall also be given to any accompanying controlled airspace requirements in order to conserve airspace to the extent it is feasible. See figure 1.

215. CONTROLLING OBSTACLE(S). The controlling obstacle in the final approach segment shall be identified in procedures submitted for publication.

216.-219. RESERVED.

SECTION 2. EN ROUTE OPERATIONS

220. FEEDER ROUTES. When the IAF is part of the en route structure, there may be no need to designate additional routes for aircraft to proceed to the IAF. In some cases, however, it is necessary to designate feeder routes from the en route structure to the IAF. Only those feeder routes which provide an operational advantage shall be established and published. These should coincide with the local air traffic flow. The length of the feeder route shall not exceed the operational service volume of the facilities which provide navigational guidance, unless additional frequency protection is provided. En route airway obstacle clearance criteria shall apply to feeder routes. The minimum altitude established on feeder routes shall not be less than the altitude established at the IAF.

a. Construction of a feeder route connecting to a course reversal segment. The area considered for obstacle evaluation is oriented along the feeder route at a width appropriate to the type of route (VOR or NDB). The area terminates at the course reversal fix, and is defined by a line perpendicular to the feeder course through the course reversal fix.

b. The angle of intersection between the feeder route course and the next straight segment (feeder/initial) course shall not exceed 120°.

c. Descent Gradient. The OPTIMUM descent gradient in the feeder route is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per mile. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible is 1,000 feet per mile.

221. MINIMUM SAFE/SECTOR ALTITUDES (MSA). A minimum safe altitude provides at least 1,000 feet of obstacle clearance for emergency use, within a specified distance from the RNAV WP/primary navigation facility upon which a procedure is predicated. Minimum altitudes are identified as minimum safe altitudes or emergency safe altitudes, and are rounded to the next higher 100-foot increment.

a. MSA. Establish an MSA for all procedures within a 25-mile radius of the WP/facility, including the area 4 miles beyond the outer boundary. When the distance from the facility to the airport exceeds 25 miles, extend the radius to include the airport landing surfaces up to a maximum distance of 30 miles. See figure 2-1. When the procedure does not use an omnidirectional facility; e.g., LOC BC with a fix for the FAF, use the primary omnidirectional facility in the area. If necessary to offer relief from obstacles, establish sector divisions, or a common safe altitude (no sectors) for the entire area around the facility. Sectors shall not be less than 90° in spread. Sector altitudes should be raised and combined with adjacent higher sectors when the altitude difference does not exceed 300 feet. A sector altitude shall also provide 1,000 feet of obstacle clearance in any adjacent sector within 4 miles of the sector boundary line. For area navigation (RNAV) procedures establish a common safe altitude within the specified radius of the runway waypoint (RWY WP) for straight-in approaches; or the airport waypoint (APT WP) for circling procedures; for GPS approaches, from the WP used for the MSA center (see figure 2-2).

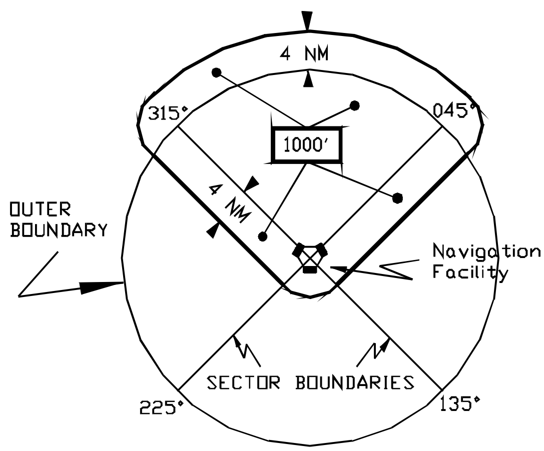


Figure 2-1. Non-RNAV MSA. Par 221.

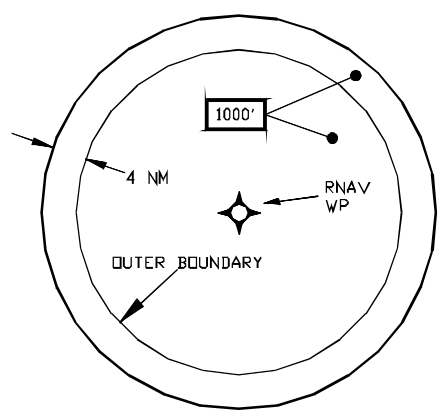


Figure 2-2. RNAV MSA. Par 221.

b. Emergency Safe Altitudes (ESA). ESA's are normally developed only for military procedures, and at the option of the approving authority. Establish ESA's within a 100-mile radius of the navigation facility or WP used as the ESA center, with a common altitude for the entire area. Where ESA's are located in designated mountainous areas, provide at least 2,000 feet of obstacle clearance.

222.-229. RESERVED.

SECTION 3. INITIAL APPROACH

230. INITIAL APPROACH SEGMENT. The instrument approach commences at the IAF. In the initial approach, the aircraft has departed the en route phase of flight and is maneuvering to enter an intermediate segment. When the IF is part of the en route structure, it may not be necessary to designate an initial approach segment. In this case, the approach commences at the IF and intermediate segment criteria apply. An initial approach may be made along an arc, radial, course, heading, radar vector, or a combination thereof. Procedure turns, holding pattern descents, and high altitude penetrations are initial segments. Positive course guidance (PCG) is required except when dead reckoning (DR) courses can be established over limited distances. Although more than one initial approach may be established for a procedure, the number should be limited to that which is justified by traffic flow or other operational requirements. Where holding is required prior to entering the initial approach segment, the holding fix and IAF should coincide. When this is not possible, the IAF shall be located within the holding pattern on the inbound holding course.

231. ALTITUDE SELECTION. Minimum altitudes in the initial approach segment shall be established in 100-foot increments; i.e., 1,549 feet may be shown as 1,500 feet and 1,550 feet shall be shown as 1,600 feet. The altitude selected shall not be below the PT altitude where a PT is required. In addition, altitudes specified in the initial approach segment must not be lower than any altitude specified for any portion of the intermediate or final approach segment.

232. INITIAL APPROACH SEGMENTS BASED ON STRAIGHT COURSES AND ARCS WITH PCG.

a. Alignment.

(1) Courses. The angle of intersection between the initial approach course and the intermediate course shall not exceed 120°. When the angle exceeds 90°, a radial or bearing which provides at least 2 miles of lead shall be identified to assist in leading the turn onto the intermediate course (see figure 3).

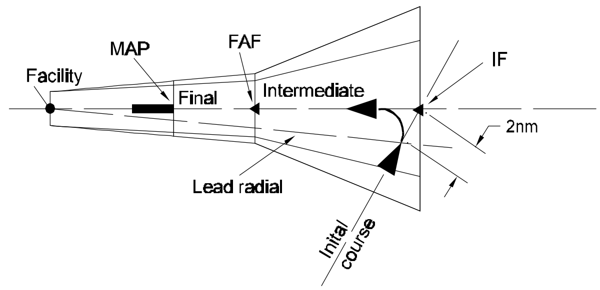


Figure 3. INITIAL APPROACH INTERCEPTION ANGLE GREATER THAN 90°. Par 232a(1).

(2) Arcs. An arc may provide course guidance for all or a portion of an initial approach. The minimum arc radius shall be 7 miles, except for high altitude jet penetration procedures, in which the minimum radius should be at least 15 miles. When an arc of less than 15 miles is used in high altitude procedures, the descent gradient along the arc shall not exceed the values in table 1. An arc may join a course at or before the IF. When joining a course at or before the IF, the angle of intersection of the arc and the course shall not exceed 120°. When the angle exceeds 90°, a radial which provides at least 2 miles of lead shall be identified to assist in leading the turn on to the intermediate course. DME arc courses shall be predicated on DME collocated with a facility providing omnidirectional course information.

Table 1. DESCENT GRADIENT ON AN ARC. Par 232a(2).

MILES	MAX FT. PER NM
15	**1,000**
14	**720**
13	**640**
12	**560**
11	**480**
10	**400**
9	**320**
8	**240**
7	**160**

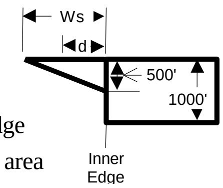
b. Area. The initial approach segment has no standard length. The length shall be sufficient to permit the altitude change required by the procedure and shall not exceed 50 miles unless an operational requirement exists. The total width of the initial approach segment shall be 6 miles on each side of the initial approach course. This width is divided into a primary area, which extends laterally 4 miles on each side of the course, and a secondary area, which extends laterally 2 miles on each side of the primary area. See figure 10. When any portion of the initial approach is more than 50 miles from the navigation facility, the criteria for en route airways shall apply to that portion.

c. Obstacle Clearance. The obstacle clearance in the initial approach primary area shall be a minimum of 1,000 feet. In the secondary area 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{Ws - d}{Ws}$$

Where d = distance from inner edge

Ws = Width of secondary area



Allowance for precipitous terrain should be made as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to nearest 100 feet. See paragraph 231.

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM gradient is 500 feet per mile. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM gradient is 1,000 feet per mile.

233. INITIAL APPROACH SEGMENT BASED ON DR. See ILS Chapter for special limitations.

a. Alignment. Each DR course shall intercept the extended intermediate course. For LOW altitude procedures, the intercept point shall be at least 1 mile from the IF for each 2 miles of DR flown. For HIGH altitude procedures, the intercept point may be 1 mile for each 3 miles of DR flown. The intercept angle shall:

(1) Not exceed 90°

(2) Not be less than 45° except when DME is used OR the DR distance is 3 miles or less.

b. Area. The MAXIMUM length of the DR portion of the initial segment is 10 miles (except paragraph 232b applies for HIGH altitude procedures where DME is available throughout the DR segment). Where the DR course begins, the width is 6 miles on each side of the course, expanding by 15° outward until joining the points shown in figures 4-1, 4-2, 4-3, 4-4, and 4-5.

c. Obstacle Clearance. The obstacle clearance in the DR initial approach segment shall be a minimum of 1,000 feet. There is no secondary area. Allowance for precipitous terrain should be considered as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet (see paragraph 231).

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per mile. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 1,000 feet per mile.

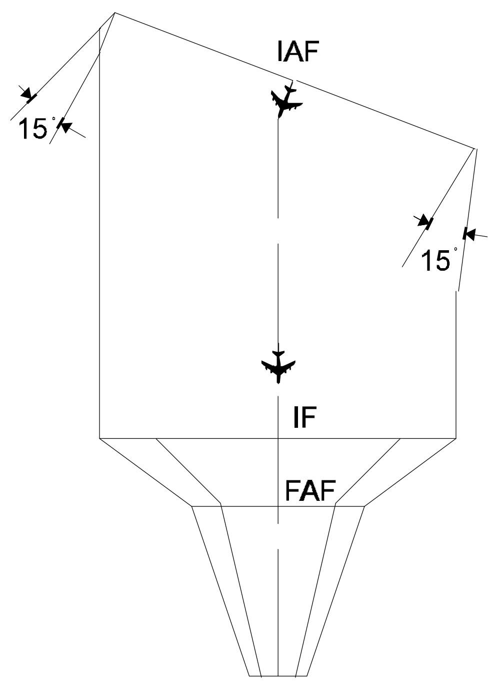


Figure 4-1. MOST COMMON DR SEGMENT. Par 233b.

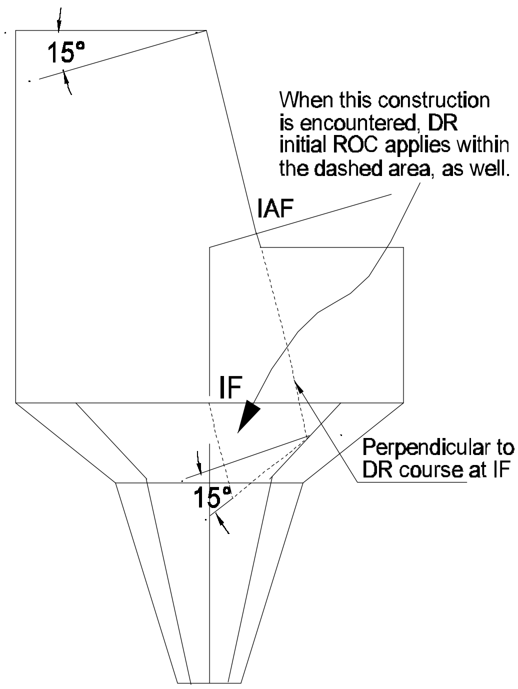


Figure 4-2. DR SEGMENT WITH BOUNDARY INSIDE THE INTERMEDIATE SEGMENT. Par 233b.

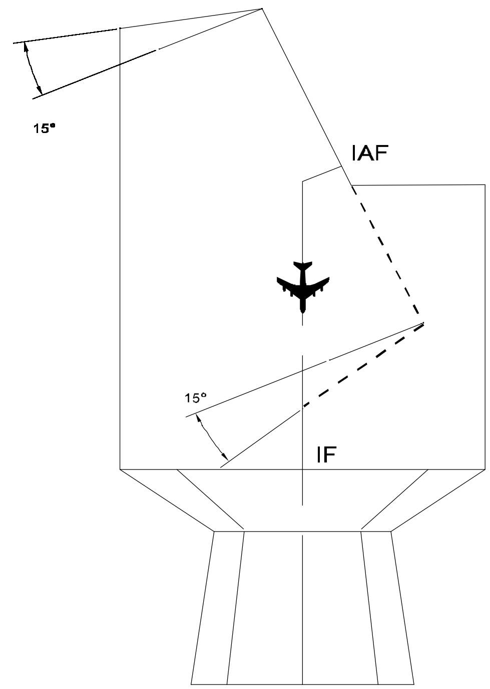


Figure 4-4. DR INITIAL SEGMENT WITH BOUNDARY INSIDE THE STRAIGHT INITIAL SEGMENT. Par 233b.

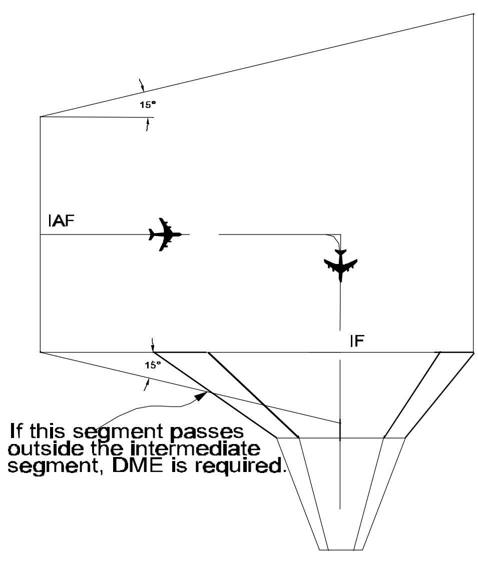


Figure 4-3. DR SEGMENT WITH BOUNDARY INTERCEPTING THE INTERMEDIATE SEGMENT. Par 233b.

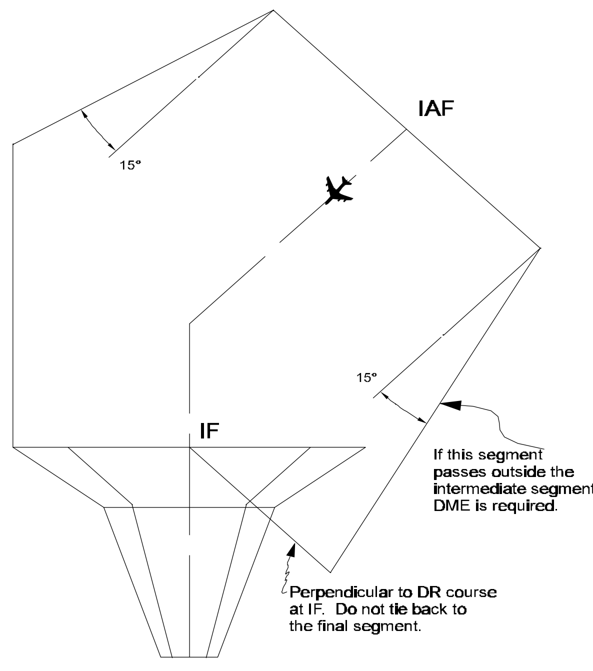


Figure 4-5. DR INITIAL SEGMENT WITH BOUNDARY OUTSIDE THE INTERMEDIATE SEGMENT. Par 233b.

234. INITIAL APPROACH SEGMENT BASED ON A PT. A PT shall be specified when it is necessary to reverse direction to establish the aircraft on an intermediate or FAC, except as specified in paragraph 234e. A PT begins by overheading a facility or fix which meets the criteria for a holding fix (see paragraph 287b), or for a FAF (see paragraph 287c). The procedure shall specify the PT fix, the outbound and inbound course, the distance within which the PT shall be completed, and the direction of the PT. When a teardrop turn is used, the angle of divergence between the outbound course and the reciprocal of the inbound course shall be a MINIMUM of 15° or a MAXIMUM of 30° (see paragraph 235a for high altitude teardrop penetrations). When the beginning of the intermediate or final approach segment associated with the procedure turn is not marked by a fix, the segment is deemed to begin on the inbound procedure turn course at the maximum distance specified in the procedure. Where neither segment is marked by a fix, the final segment begins at the maximum distance specified in the procedure.

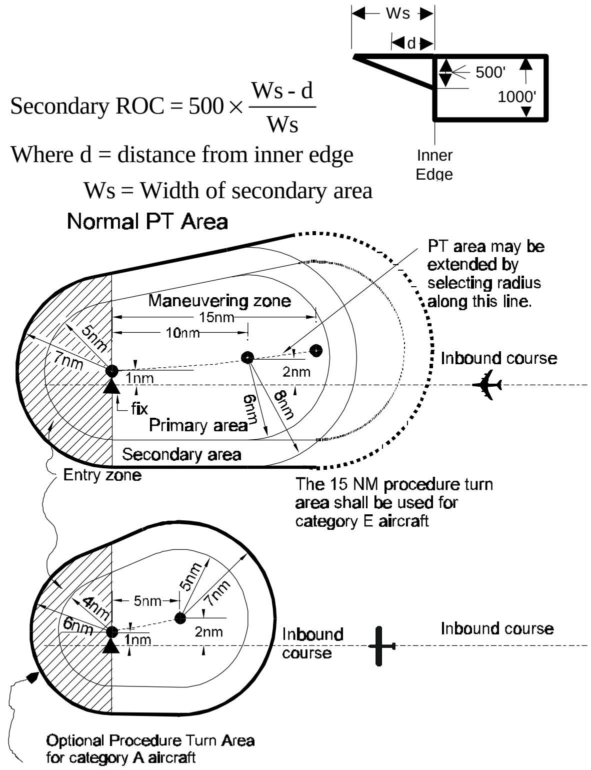


Figure 5. PT AREAS. Par 234b.

a. Alignment. When the inbound course of the PT becomes the intermediate course, it must meet the intermediate course alignment criteria (see paragraph 242a). When the inbound course becomes the FAC, it must meet the FAC alignment criteria (see paragraph 250). The wider side of the PT area shall be oriented in the same direction as that prescribed for the PT.

b. Area. The PT areas are depicted in figure 5. The normal PT distance is 10 miles. This distance may be decreased to 5 miles where only approach CAT "A" aircraft are to be operated and may be increased to as much as 15 miles or as specified in paragraph 234d. No extension of the PT is permitted without a FAF. When a PT is authorized for use by approach CAT "E" aircraft, a 15-mile PT distance shall be used. The PT segment is divided into zones and areas: the entry zone, the maneuvering zone, the primary area, and the secondary area (see figure 5). The entry zone is the zone in which entry is made into the maneuvering zone. The entry zone inner boundary extends perpendicular to the inbound course at the PT fix. The remainder of the PT segment is the maneuvering zone. The maneuvering zone and entry are made up of primary and secondary areas. The secondary area width is 2 miles on the outside of the primary area.

c. Obstacle Clearance. A minimum of 1,000 feet of clearance shall be provided in the primary area. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. Allowance for precipitous terrain should be considered as specified in paragraph 323a. The primary and secondary areas determine obstacle clearance in both the entry and maneuvering zones. The use of entry and maneuvering zones provides further relief from obstacles. The entry zone is established to control the obstacle clearance prior to proceeding outbound from the PT fix. The maneuvering zone is established to control obstacle clearance AFTER proceeding outbound from the PT fix (see figure 6). The altitudes selected by application of the obstacle clearance as specified in this paragraph may be rounded to the nearest 100 feet (see paragraph 231).

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per mile. Where a PT is established over a FAF, the PT completion altitude should be as close as possible to the FAF altitude. The difference between the PT completion altitude and the altitude over the FAF shall not be greater than those shown in table 1A. If greater differences are required for a 5- or 10-mile PT, the PT distance limits and maneuvering zone shall be increased at the rate of 1 mile for each 200 feet of required altitude.

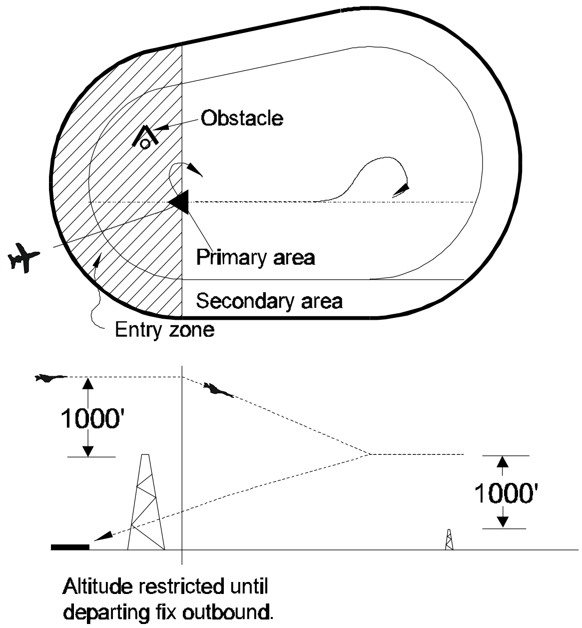


Figure 6. PT INITIAL APPROACH AREA. Par 234c.

e. Elimination of PT. A PT is NOT required when an approach can be made direct from a specified IF to the FAF. A PT NEED NOT be established when an approach can be made from a properly aligned holding pattern. See paragraph 291. In this case, the holding pattern in lieu of a PT, shall be established over a final or intermediate approach fix and the following conditions apply:

(1) If the holding pattern is established over the FAF, the minimum holding altitude (MHA) shall not be more than 300 feet above the altitude specified for crossing the FAF inbound.

(2) If the holding pattern is established over the IF, the MHA shall permit descent to the FAF altitude within the descent gradient tolerances prescribed for the intermediate segment (see paragraph 242d).

Table 1A. PT COMPLETION ALTITUDE DIFFERENCE. Par 234d.

TYPE OF PT	ALTITUDE DIFFERENCE
15 Mile PT from FAF	Within 3,000 Ft of Alt. over FAF
10 Mile PT from FAF	Within 2,000 Ft of Alt. over FAF
5 Mile PT from FAF	Within 1,000 Ft of Alt. over FAF
15 Mile PT, no FAF	Not Authorized
10 Mile PT, no FAF	Within 1,500 Ft of MDA on Final
5 Mile PT, no FAF	Within 1,000 Ft of MDA on Final

235. INITIAL APPROACH BASED ON HIGH ALTITUDE TEARDROP PENETRATION. A teardrop penetration consists of departure from an IAF on an outbound course, followed by a turn toward and intercepting the inbound course at or prior to the IF or point. Its purpose is to permit an aircraft to reverse direction and lose considerable altitude within reasonably limited airspace. Where no IF is available to mark the beginning of the intermediate segment, it shall be assumed to commence at a point 10 miles prior to the FAF. When the facility is located on the airport, and no fix is available to mark the beginning of the final approach segment, the criteria in paragraph 423 apply.

a. Alignment. The outbound penetration course shall be between 18° and 26° to the left or right of the reciprocal of the inbound course. The actual angular divergence between the courses will vary inversely with the distance from the facility at which the turn is made (see table 2).

b. Area.

(1) Size. The size of the penetration turn area must be sufficient to accommodate both the turn and the altitude loss required by the procedure. The penetration turn distance shall not be less than 20 miles from the facility. The penetration turn distance depends on the altitude to be lost in the procedure and the point at which the descent is started (see table 2). The aircraft should lose half the total altitude or 5,000 feet, whichever is greater, outbound prior to starting the turn. The penetration turn area has a width of 6 miles on both sides of the flight track up to the IF or point, and shall encompass all the areas within the turn (see figure 7).

Table 2. PENETRATION TURN DISTANCE/DIVERGENCE. Par 235a.

ALT TO BE LOST PRIOR TO COM-MENCING TURN	DISTANCE TURN COM-MENCES (NM)	COURSE DIVER-GENCE (DEGREES)	SPECIFIED PENETRATION TURN DIS-TANCE (NM)
12,000 Ft	24	18	28
11,000 Ft	23	19	27
10,000 Ft	22	20	26
9,000 Ft	21	21	25
8,000 Ft	20	22	24
7,000 Ft	19	23	23
6,000 Ft	18	24	22
5,000 Ft	17	25	21
5,000 Ft	16	26	20

(2) Penetration Turn Table. Table 2 should be used to compute the desired course divergence and penetration turn distances which apply when a specific altitude loss outbound is required. It is assumed that the descent begins at the plotted position of fix. When the procedure requires a delay before descent of more than 5 miles, the distance in excess of 5 miles should be added to the distance the turn commences. The course divergence and penetration turn distance should then be adjusted to correspond to the adjusted turn distance. Extrapolations may be made from the table.

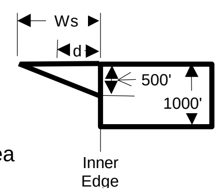
(3) Primary and Secondary Areas. All of the penetration turns area, except the outer 2 miles of the 6-mile obstacle clearance area on the outer side of the penetration track, is primary area. See figure 7. The outer 2 miles is secondary area. The outer 2 miles on both sides of the inbound penetration course should be treated as secondary area.

c. Obstacle Clearance. Obstacle clearance in the initial approach primary area shall be a MINIMUM of 1,000 feet. Obstacle clearance at the inner edge of the secondary area shall be 500 feet, tapering to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{Ws - d}{W_s}$$

Where d = distance from inner edge

Ws = Width of secondary area



Where no IF is available, a 10 NM intermediate segment is assumed and intermediate segment required obstacle clearance (ROC) is applied. The controlling obstacle, as well as the minimum altitude selected for the intermediate segment, may depend on the availability of an IF. See figure 8. Allowance for precipitous terrain should be considered in the penetration turn area as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet. See paragraph 231.

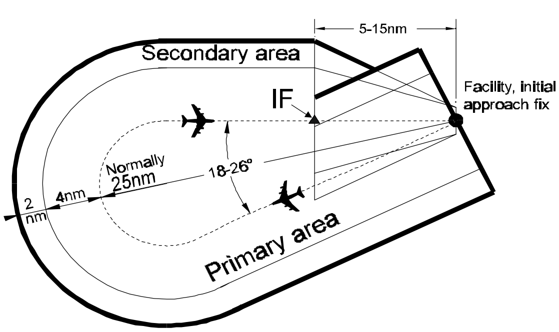


Figure 7. TYPICAL PENETRATION TURN INITIAL APPROACH AREA. Par 235.

d. Descent Gradient. The OPTIMUM descent gradient is 800 feet per mile. The MAXIMUM gradient is 1,000 feet per mile.

e. Penetration Turn Altitude. When an IF is NOT provided, the penetration turn completion altitude shall not be more than 4,000 feet above the FAF altitude.

236. INITIAL APPROACH COURSE REVERSAL USING NONCOLLOCATED FACILITIES AND A TURN OF 120° OR GREATER TO INTERCEPT THE INBOUND COURSE. See figures 9-1, 9-2 and 9-3.

a. Common Criteria.

(1) A turn point fix shall be established as shown in the figures. The fix error shall meet section 8 criteria and shall not exceed ± 2 NM.

(2) A flightpath radius of 2.8 NM shall be used for procedures where the altitude at the turn point fix is at or before 10,000 feet, or 4 NM for procedures where the altitude at the turn point fix is above 10,000 feet MSL.

(3) Descent Gradient. Paragraph 232d applies.

(4) Obstacle Clearance. Paragraph 235c applies.

(5) Initial Distance. When the course reversal turn intercepts the extended intermediate course, and when the course reversal turn intercepts a straight segment prior to intercepting the extended intermediate course, the minimum distance between the rollout point and the FAF is 10 NM.

(6) ROC Reduction. No reduction of secondary ROC is authorized in the course reversal area unless the turn point fix is DME.

b. Figures 9-1 and 9-2. The rollout point shall be at or prior to the IF/point.

(1) Select the desired rollout point on the inbound course.

(2) Place the appropriate flightpath arc tangent to the rollout point.

(3) From the outbound facility, place the outbound course tangent to the flightpath arc. The point of tangency shall be the turn point fix.

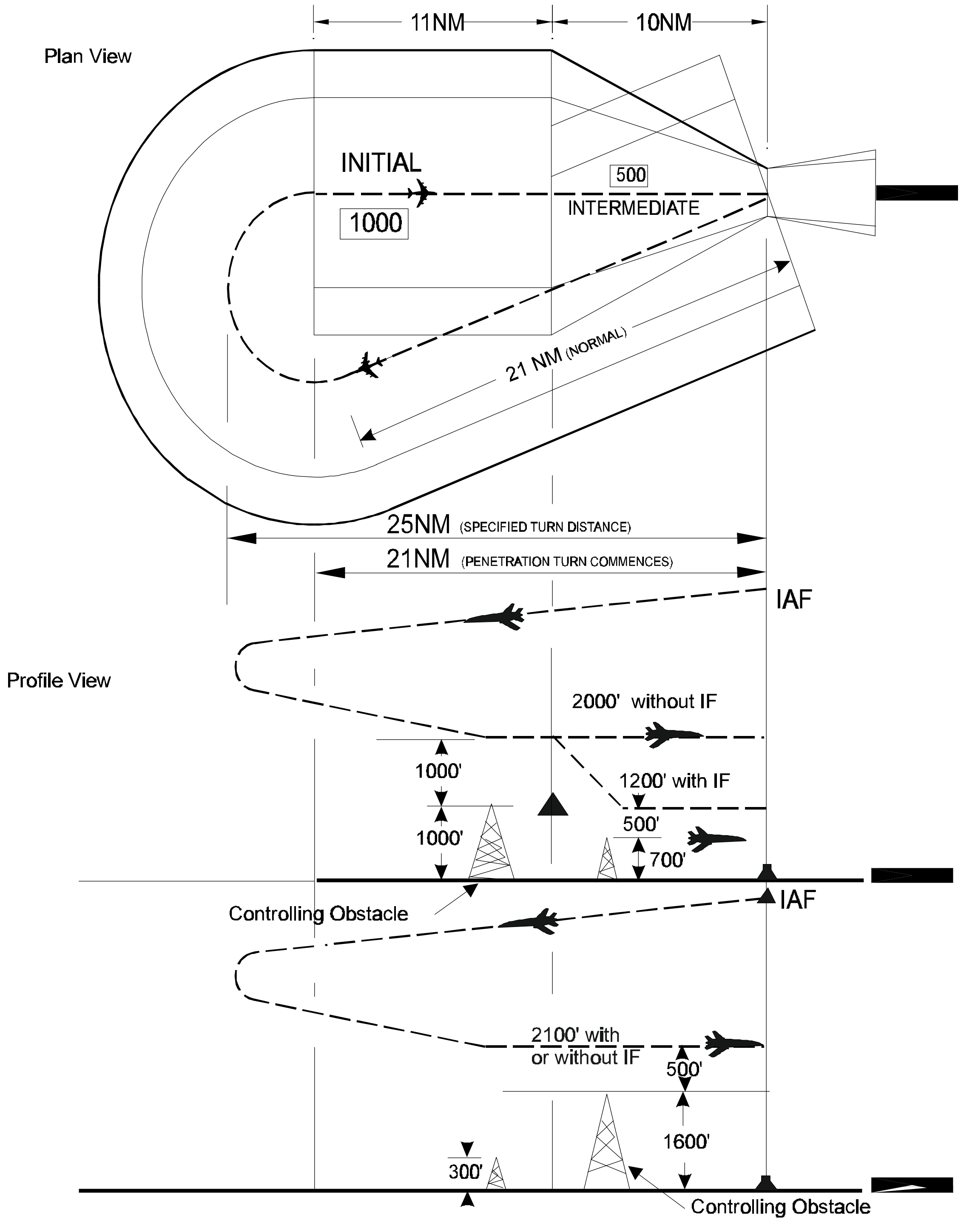
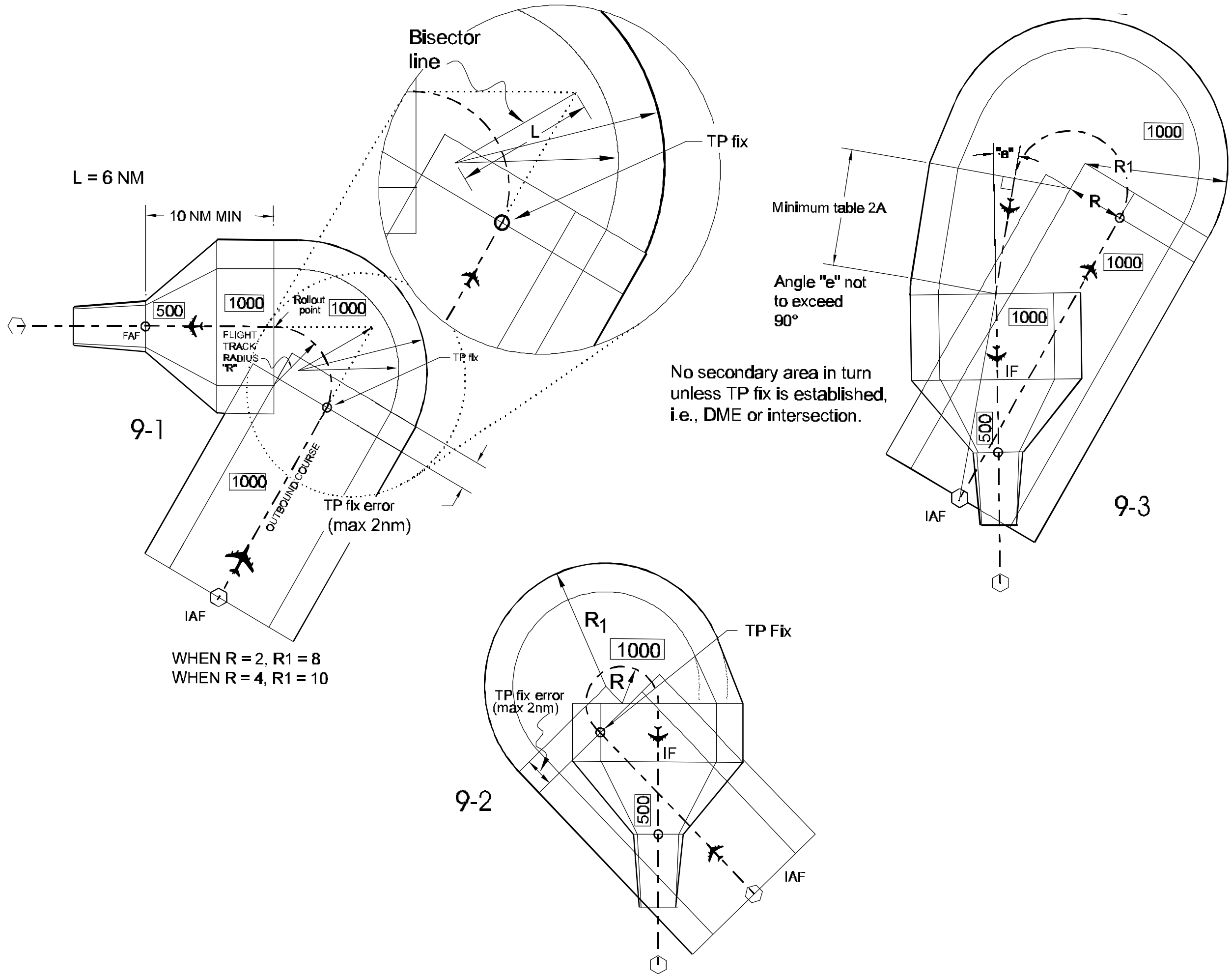


Figure 8. PENETRATION TURN INITIAL APPROACH OBSTACLE CLEARANCE. Par 235c.



Figures 9-1, 9-2, and 9-3. EXAMPLES OF INITIAL APPROACH COURSE REVERSAL. Par 236.

c. Figure 9-3

(1) The point of intersection shall be at or prior to the IF/point (paragraph 242 applies). The angle shall be 90° or less.

(2) The distance between the roll-out point and the point of intersection shall be no less than the distance shown in table 2A.

(3) Paragraph 235 and table 2 should be used for high altitude procedures up to the point of intersection of the two inbound courses.

Table 2A. MINIMUM DISTANCE FROM ROLL OUT POINT TO POINT OF INTERSECTION. Par. 236c(2).

ANGLE "a" (DEGREES)	NM
0 - 15	1
>15 - 30	2
>30 - 45	3
>45 - 60	4
>60 - 75	5
>75 - 90	6

(4) Select the desired point of intersection. From the outbound facility draw a line through the point of intersection.

(5) At the outbound facility, measure the required number of degrees course divergence (may be either side of the line through the point of intersection) and draw the outbound course out the required distance. Connect the outbound course and the line through the point of intersection with the appropriate arc.

(6) Determine the desired rollout point on the line through the point of intersection.

(a) Place the appropriate flightpath arc tangent to the rollout point.

(b) From the outbound facility draw the outbound course tangent to the flightpath arc. The point of tangency is the turn point fix.

237.-239. RESERVED.

SECTION 4. INTERMEDIATE APPROACHES

240. INTERMEDIATE APPROACH SEGMENT. This is the segment which blends the initial approach segment into the final approach segment. It is the segment in which aircraft configuration, speed, and positioning adjustments are made for entry into the final approach segment. The intermediate segment begins at the IF, or point, and ends at the FAF. There are two types of intermediate segments; the "radial" or "course" intermediate segment and the "arc" intermediate segment. In either case, PCG shall be provided. See figure 10 for typical approach segments.

241. ALTITUDE SELECTION. The MINIMUM altitude in the intermediate segment shall be established in 100-foot increments; i.e., 749 feet may be shown as 700 feet and 750 feet shall be shown as 800. In addition, the altitude selected for arrival over the FAF shall be low enough to permit descent from the FAF to the airport for a straight-in landing whenever possible.

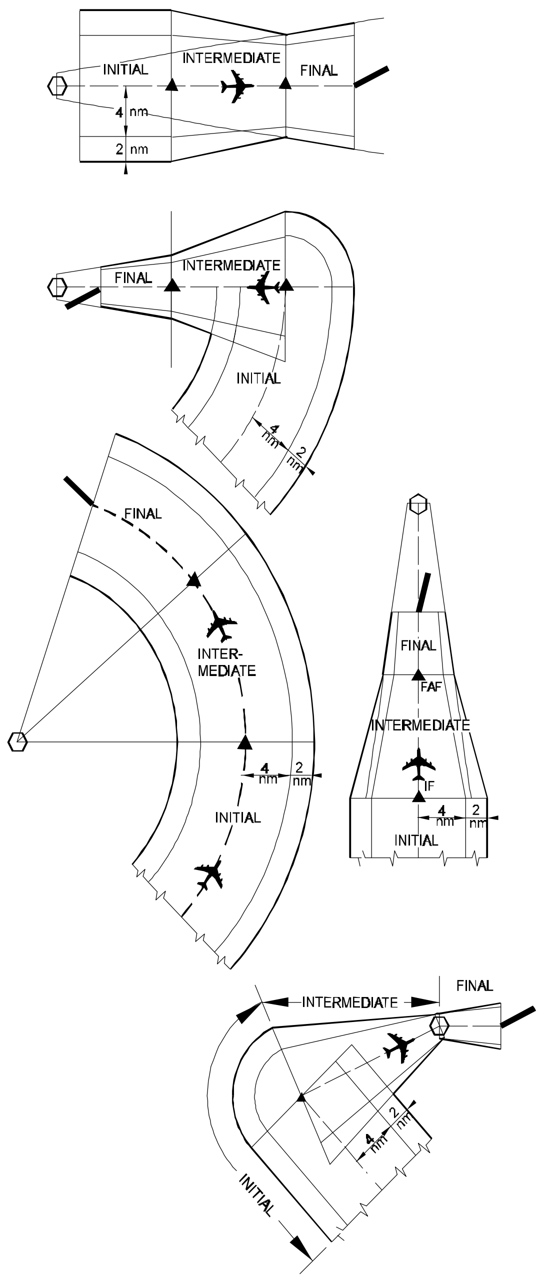


Figure 10. TYPICAL APPROACH SEGMENTS. Par 232b and 240.

242. INTERMEDIATE APPROACH SEGMENT BASED ON STRAIGHT COURSES.

a. Alignment. The course to be flown in the intermediate segment shall be the same as the FAC, except when the FAF is the navigation facility and it is not practical for the courses to be identical. In such cases, the intermediate course shall not differ from the FAC by more than 30°.

b. Area.

(1) Length. The intermediate segment shall not be less than 5 miles (except as provided for in chapters 9 and 10) nor more than 15 miles in length, measured along the course to be flown. The OPTIMUM length is 10 miles. A distance greater than 10 miles should not be used unless an operational requirement justifies a greater distance. When the angle at which the initial approach course joins, the intermediate course exceeds 90° (see figure 3), the MINIMUM length of the intermediate course is as shown in table 3.

(2) Width. The width of the intermediate segment is the same as the width of the segment it joins. When the intermediate segment is aligned with initial or final approach segments, the width of the intermediate segment is determined by joining the outer edges of the initial segment with the outer edges of the final segment. When the intermediate segment is not aligned with the initial or final approach segments, the resulting gap on the outside of the turn is a part of the preceding segment and is closed by the appropriate arc (See figure 10). For obstacle clearance purposes, the intermediate segment is divided into a primary and a secondary area.

Table 3. MINIMUM INTERMEDIATE COURSE LENGTH. Par 242b(1).

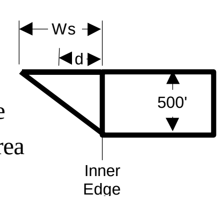
ANGLE (DEGREES)	MINIMUM LENGTH (MILES)
91 - 96	6
>96 - 102	7
>102 -108	8
>108 -114	9
>114 - 120	10

c. Obstacle Clearance. A MINIMUM of 500 feet of obstacle clearance shall be provided in the primary area of the intermediate approach segment. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{\text{Ws - d}}{\text{Ws}}$$

Where d = distance from inner edge

Ws = Width of secondary area



Allowance for precipitous terrain should be considered as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet. See paragraph 241.

d. Descent Gradients. Because the intermediate segment is used to prepare the aircraft speed and configuration for entry into the final approach segment, the gradient should be as flat as possible. The OPTIMUM descent gradient is 150 feet per mile. The MAXIMUM gradient is 318 feet per mile, except for a localizer approach published in conjunction with an ILS procedure. In this case, a higher descent gradient equal to the commissioned GS angle (provided it does not exceed 3°) is permissible. Higher gradients resulting from arithmetic rounding are also permissible.

NOTE: When the descent gradient exceeds 318 feet per mile, the procedure specialist should assure a segment is provided prior to the intermediate segment to prepare the aircraft speed and configuration for entry into the final segment. This segment should be a minimum length of 5 miles and its descent gradient should not exceed 318 feet per mile.

243. INTERMEDIATE APPROACH SEGMENT BASED ON AN ARC. Arcs with a radius of less than 7 miles or more than 30 miles from the navigation facility shall NOT be used. DME arc courses shall be predicated on DME collocated with a facility providing omnidirectionalional course information.

a. Alignment. The same arc shall be used for the intermediate and the final approach segments. No turns shall be required over the FAF.

b. Area.

(1) Length. The intermediate segment shall NOT be less than 5 miles nor more than 15 miles in length, measured along the arc. The OPTIMUM length is 10 miles. A distance greater than 10 miles should not be used unless an operational requirement justifies the greater distance.

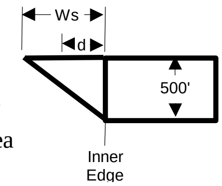
(2) Width. The total width of an arc intermediate segment is 6 miles on each side of the arc. For obstacle clearance purposes, this width is divided into a primary and a secondary area. The primary area extends 4 miles laterally on each side of the arc segment. The secondary areas extend 2 miles laterally on each side of the primary area (see figure 10).

c. Obstacle Clearance. A MINIMUM of 500 feet of obstacle clearance shall be provided in the primary area. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge.

$$\text{Secondary ROC} = 500 \times \frac{\text{Ws - d}}{\text{Ws}}$$

Where d = distance from inner edge

Ws = Width of secondary area



Allowance for precipitous terrain should be considered as specified in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet. (see paragraph 241).

d. Descent Gradients. Criteria specified in paragraph 242d shall apply.

244. INTERMEDIATE APPROACH SEGMENT WITHIN A PT.

a. PT Over a FAF. When the FAF is a Facility (see figure 11).

(1) The MAXIMUM intermediate length is 15 NM, the OPTIMUM is 10 NM, and the MINIMUM is 5 NM. Its width is the same as the final segment at the facility and expanding uniformly to 6 NM on each side of the course at 15 NM from the facility.

(2) The intermediate segment considered for obstacle clearance shall be the same length as the PT distance; e.g., if the procedure requires a PT to be completed within 5 NM, the intermediate segment shall be only 5 NM long, and the intermediate approach shall begin on the intermediate course 5 NM from the FAF.

(3) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) Table 1A shall be applied.

(b) Only one stepdown fix is authorized within the intermediate segment that underlies the PT maneuvering area.

(c) The distance between the PT fix/facility and a stepdown fix underlying the PT area shall not exceed 4 NM.

(d) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

Figure 11. INTERMEDIATE AREA WITHIN A PT AREA. FAF is the Facility. Par 244a.

b. PT Over a FAF when the FAF is NOT a Facility (See figure 12).

(1) The intermediate segment shall be 6 NM wide each side of the intermediate course at the PT distance.

(2) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) Table 1A shall be applied.

(b) Only one stepdown fix is authorized within the intermediate segment that underlies the PT maneuvering area.

(c) The distance between the PT fix/facility and a stepdown fix underlying the PT area shall not exceed 4 NM.

(d) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

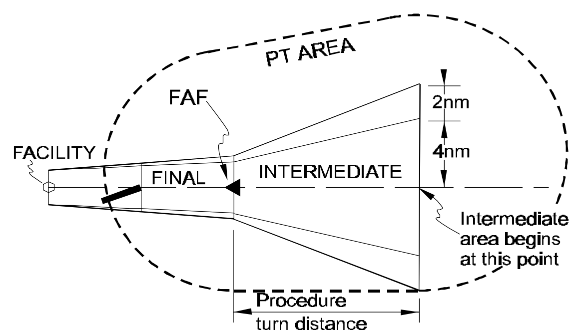


Figure 12. INTERMEDIATE AREA WITHIN THE PT AREA. FAF is not the Facility. Par 244b.

c. PT Over a Facility/Fix AFTER the FAF. See figure 13.

(1) The PT facility/fix to FAF distance shall not exceed 4 NM.

(2) The MAXIMUM PT distance is 15 NM.

(3) The length of the intermediate segment is from the start of the PT distance to the FAF and the MINIMUM length shall be 5 NM.

Figure 13. INTERMEDIATE AREA WITHIN THE PT AREA. PT Over the Facility/Fix After the FAF. Par 244c.

(4) Intermediate Segment Area.

(a) PT Over a Facility. The intermediate segment starts 15 NM from the facility at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(b) PT Over a Fix (NOT a Facility). The intermediate segment starts at the PT distance at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(5) The MAXIMUM descent gradient in the intermediate segment is 200 feet/NM. The PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(6) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) Only one stepdown fix is authorized within the intermediate segment that underlies the PT maneuvering area.

(b) The distance between the PT fix/facility and a stepdown fix underlying the PT area shall not exceed 4 NM.

(c) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

d. PT Over a Facility/Fix PRIOR to the FAF. See figures 14-1 and 14-2.

Figure 14-1. INTERMEDIATE AREA WITHIN THE PT AREA. PT Over the Facility/Fix Prior to the FAF. Par 244d.

(1) The MINIMUM PT distance is 5 NM.

(2) The length of the intermediate segment is from the start of the PT distance to the FAF and the MAXIMUM length is 15 NM.

(3) Intermediate Segment Area.

(a) PT Over a Facility. The intermediate segment starts 15 NM from the facility at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

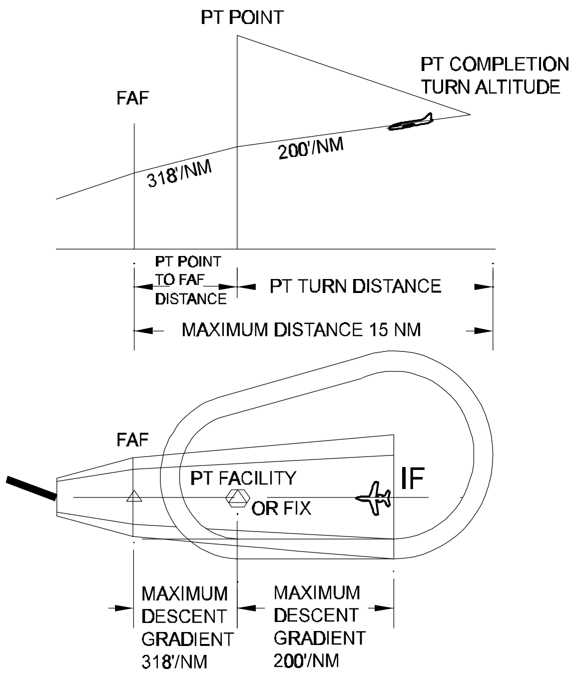


Figure 14-2. INTERMEDIATE AREA WITHIN PT AREA. PT Facility/Fix Used as a Stepdown Fix. Par 244d(4).

(b) PT Over a Fix (NOT a Facility). The intermediate segment starts at the PT distance at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(4) The MAXIMUM descent gradient is 200 feet/NM. If the PT facility/fix is a stepdown fix, the descent gradient from the stepdown fix to the FAF may be increased to a maximum of 318 feet/NM (see figure 14-2). The PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(5) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) When the PT fix is over a facility/fix prior to the FAF, the facility/fix is the stepdown fix in the intermediate/initial area, and another stepdown fix within this segment is not authorized.

(b) The MAXIMUM descent gradient from the IF point to the stepdown fix is 200 feet/NM. The MAXIMUM descent gradient from the stepdown fix to the FAF is 318 feet/NM.

e. PT Facility Fix Used as an IF. See figure 14-3.

(1) When the PT inbound course is the same as the intermediate course, either paragraph 244d may be used, or a straight initial segment may be used from the start of the PT distance to the PT fix.

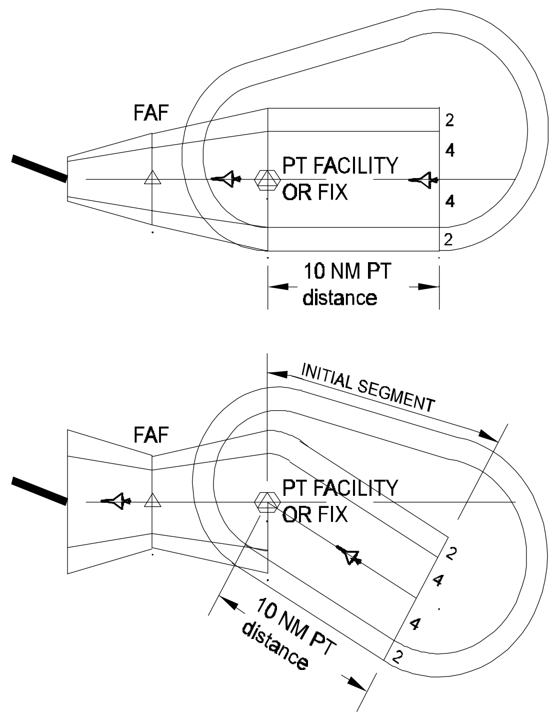


Figure 14-3. USE OF PT FIX FOR IF. Par 244e.

(2) When the PT inbound course is NOT the same as the intermediate course, an intermediate segment within the PT area is NOT authorized; ONLY a straight initial segment shall be used from the start of the PT distance to the PT fix.

(3) When a straight initial segment is used, the MAXIMUM descent gradient within the PT distance is 318 feet/NM, the PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(4) When establishing a stepdown fix within an intermediate/initial segment underlying a PT area:

(a) Only one stepdown fix is authorized within the initial segment that underlies the PT maneuvering area.

(b) The distance from the PT facility/fix and a stepdown fix underlying the PT area shall not exceed 4 NM.

(c) The MAXIMUM descent gradient from the PT completion point (turn distance) to the stepdown fix, and from the stepdown fix to the IF, is 318 feet/NM.

f. When a PT from a facility is required to intercept a localizer course, the PT facility is considered on the localizer course when it is located within the commissioned localizer course width.

245.-249. RESERVED.

SECTION 5. FINAL APPROACH

250. FINAL APPROACH SEGMENT. This is the segment in which alignment and descent for landing are accomplished. The final approach segment considered for obstacle clearance begins at the FAF or point and ends at the runway or missed approach point (MAP), whichever is encountered last. A visual portion within the final approach segment may be included for straight-in nonprecision approaches (see paragraph 251). Final approach may be made to a runway for a straight-in landing or to an airport for a circling approach. Since the alignment and dimensions of the non-visual portions of the final approach segment vary with the location and type of navigation facility, applicable criteria are contained in chapters designated for specific navigation facilities.

251. VISUAL PORTION OF THE FINAL APPROACH SEGMENT. Evaluate the visual area associated with each usable runway at an airport. Apply the STANDARD visual area described in paragraph 251a(1) to runways to which an aircraft is authorized to circle, and to runways with approach procedures aligned with the runway centerline. Apply the OFFSET visual area described in paragraph 251a(2) to evaluate the visual portion of a straight-in approach that is not aligned with the runway centerline. These evaluations determine if night operations must be prohibited because of close-in unlighted obstacles, or if visibility minimums must be restricted.

Note: If a runway is served by an approach procedure not aligned with the runway centerline, and is authorized for landing from a circling maneuver on an approach procedure to a different runway, it will receive both standard and offset evaluations.

a. Area.

(1) Standard

(a) Alignment. Align the visual area with the runway centerline extended.

(b) Length. The visual area begins 200 feet from the threshold (THR) at THR elevation and extends 10,000 feet out the runway centerline (see figure 14-4). The visual area ASSOCIATED WITH AN APPROACH PROCEDURE THAT *MEETS STRAIGHT-IN ALIGNMENT CRITERIA* (need not meet straight-in descent criteria) extends to the VDP location (even if one is not published) for nonprecision procedures, or to DH for precision procedures.

NOTE: When more than one set of minimums are published, use the lowest MDA to determine VDP location.

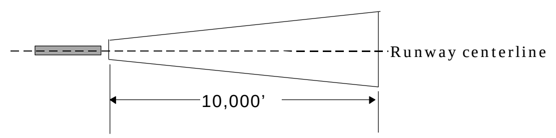


Figure 14-4. VISUAL AREA, Par. 251a(1)(b)

(c) Width. The beginning width of the visual area is 400 feet (200' either side of runway centerline) (see figure 14-5). The sides splay outward relative to runway centerline. Calculate the width of the area at any distance "d" from its origin using the following formula:

$$\tfrac{1}{2}W = (0.15 \times d) + 200'$$

where ½W = Perpendicular distance from centerline to edge of area

d = Distance (ft) measured along centerline from area origin

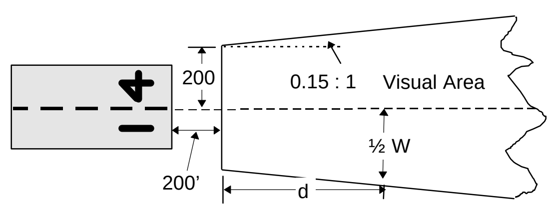


Figure 14-5. VISUAL AREA ORIGIN, Par 251a(1)(c).

(2) Offset. When the final course does not coincide with the runway centerline extended (± 0.05°), modify the visual area as follows: (See figure 14-6)

(a) STEP 1. Draw the area aligned with the runway centerline as described in paragraph 251a(1).

(b) STEP 2. Extend a line perpendicular to the final approach course (FAC) from the Visual Descent Point (VDP) (even if one is not published) to the point it crosses the Runway Centerline Extended (RCL).

(c) STEP 3. Extend a line from this point perpendicular to the RCL to the outer edge of the visual area, noting the length (L) of this extension.

(d) STEP 4. Extend a line in the opposite direction than the line in Step 2 from the VDP perpendicular to the FAC for the distance (L).

(e) STEP 5. Connect the end of the line constructed in Step 4 to the end of the inner edge of the area origin line 200 feet from runway threshold.

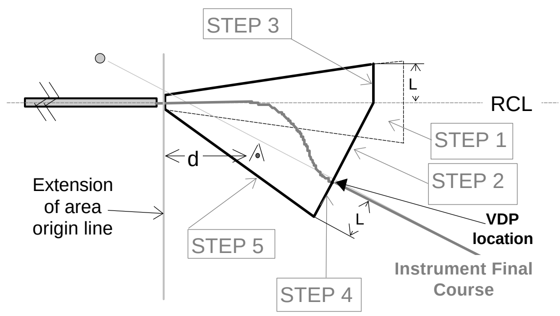


Figure 14-6. VISUAL SEGMENT FOR OFFSET COURSE, Par 251a(2).

b. Obstacle Clearance. Two obstacle identification surfaces (OIS) overlie the visual area with slopes of 20:1 and 34:1, respectively. When evaluating a runway for circling, apply the 20:1 surface. When evaluating a runway for an approach procedure satisfying straight-in alignment criteria, apply the 20:1 and 34:1 surfaces. Calculate the surface height above threshold at any distance "d" from an extension of the area origin line using following formulae:

$$\text{20:1 Surface Height} = \frac{d}{20}$$

$$\text{34:1 Surface Height} = \frac{d}{34}$$

(1) If the 34:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles.

(b) Limit minimum visibility to ¾ mile.

(2) In addition to the 34:1 evaluation, if the 20:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles.

(b) Do not publish a visual descent point (VDP), limit minimum visibility to 1 mile, and take action to have the penetrating obstacles marked and lighted.

(c) Do not publish a VDP, limit minimum visibility to 1 mile, and do not authorize night IFR operations to this runway.

252. DESCENT ANGLE/GRADIENT. The OPTIMUM nonprecision final segment descent gradient is 318 ft/NM which approximates a 3.00° angle. The MAXIMUM descent gradient is 400 ft/NM which approximates a descent angle of 3.77°. Calculate descent gradients from the plotted position of the FAF or stepdown fix to the plotted position of a stepdown fix or final endpoint (FEP) as appropriate (see figure 14-7). The FEP is formed by the intersection of the final approach course (FAC) and a line perpendicular to the FAC that extends through the runway threshold (first usable landing surface for circling only procedures). When the maximum descent gradient is exceeded, straight-in minimums are NOT authorized; however, circling only minimums may be authorized if the maximum circling descent gradient is not exceeded (see paragraph 252d).

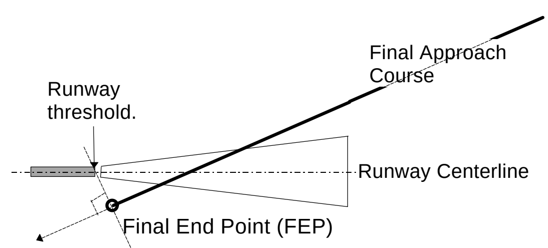


Figure 14-7. FINAL END POINT, Par 252.

a. Non-RNAV approaches. FAF and/or last step-down fix (S/D) location and altitude should be selected to provide a descent angle coincident (±0.20°) with the lowest published visual glide slope indicator (VGSI) glide slope angle, when feasible; or, when VGSI is not installed, the FAF and/or last S/D location and altitude should be selected so as to achieve a near optimum final segment descent gradient. To determine the FAF or S/D altitude necessary to align the descent angle with the lowest VGSI, calculate the altitude gain of a plane with the slope of the lowest published VGSI glide slope angle emanating from the lowest published VGSI threshold crossing height (TCH) to the FAF or S/D location. To determine the OPTIMUM FAF or S/D altitude, calculate the altitude gain of a 318 ft/NM gradient extending from the visual TCH (when there is not a VGSI, see table 18A) to the FAF or S/D location. Round this altitude up or down to the 100' increment for the FAF or 20' increment for the S/D. Ensure that ROC requirements are not violated during the rounding process. If the gradient from TCH to S/D is greater than the gradient from TCH to FAF, continue the greater gradient to the FAF and adjust the FAF altitude accordingly. If ATC or intermediate segment obstacles prohibit this altitude, consider relocating the FAF to achieve an altitude that will satisfy both the VGSI or optimum descent gradient and intermediate ROC requirements (see figure 14-8).

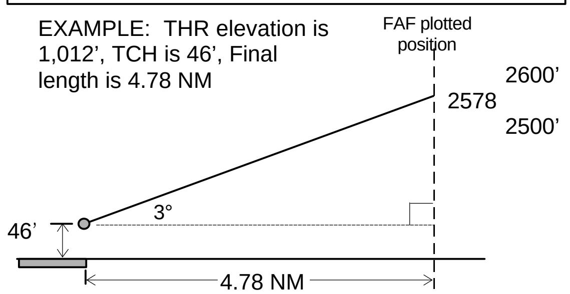
SL in NM:

$$FAF\ \text{Altitude} = \text{THRe} + \text{TCH} + (318 \times SL)$$

SL in feet:

$$\text{FAF Altitude} = \text{THRe} + \text{TCH} + \left(\tan(\text{VGSI angle}) \times SL \times 6076.11548\right)$$

where: THRe = THR Elevation
SL = Segment Length



$$2578.04 = 1012 + 46 + (318 \times 4.78)$$

or

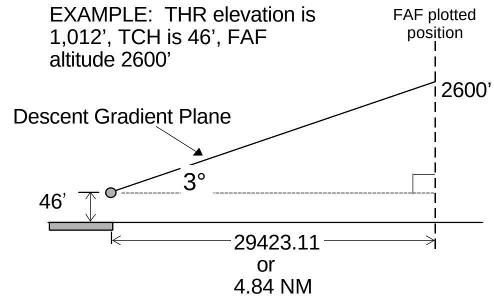
$$2580.12 = 1012 + 46 + \tan(3°) \times (4.78 \times 6076.11548)$$

Figure 14-8. FAF ACTIVITIES GIVEN FINAL LENGTH, Par 252a.

b. RNAV Approaches. If feasible, place the FAF waypoint where the optimum descent gradient plane, or the lowest published VGSI (if installed) glide slope angle intersects the intermediate altitude. When a S/D is used, the S/D altitude should be at or below the published VGSI glide slope angle (lowest angle for multi-angle systems). (see figure 14-9).

$$SL = \frac{\left(\text{FAF Altitude} - [\text{THRe} + \text{TCH}]\right)}{\tan(3° \text{ or VGSI angle})}$$

where: SL = Segment Length in feet
THRe = Threshold Elevation



$$29423.11 = \frac{2600 - (1012 + 46)}{\tan(3°)}$$

Figure 14-9. FINAL LENGTH GIVEN FAF ALTITUDE, Par 252b.

c. Determining Final Segment Descent Gradient and Angle.

(1) Final Without Stepdown Fixes. Calculate the final descent gradient by dividing the height loss from FAF to TCH by the segment length in NM.

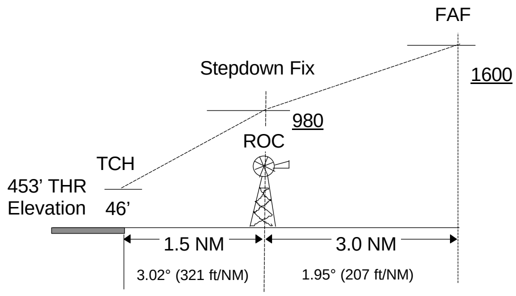
$$\text{Descent Gradient} = \frac{\text{Height Loss}}{\text{Segment Length (NM)}}$$

The descent gradient divided by 6076.11548 is the tangent of the segment descent angle(θ).

$$\text{Tan}(\theta) = \frac{\text{Descent Gradient}}{6076.11548}$$

For RNAV SIAP's, this angle is the glide slope computer setting.

(2) Final With Stepdown Fix. The maximum descent angle is calculated using the difference between the FAF/stepdown altitude and the stepdown/TCH altitude as appropriate. Descent gradient and angle computations apply to each stepdown segment. Height loss in the last segment flown is from the stepdown fix minimum altitude to the TCH (see figure 14-10).



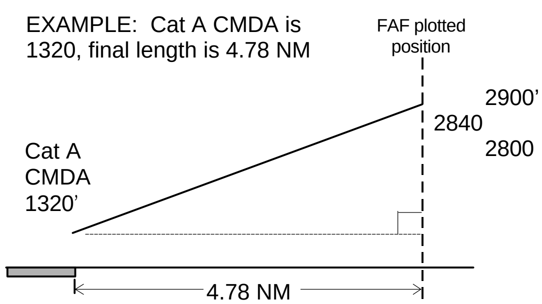
$$\text{Descent Gradient} = \frac{(1600 - 980)}{3.0}$$
$$\text{Descent Gradient} = 207 \text{ ft / NM}$$
$$\text{Tan}(\theta) = \frac{207}{6076.11548}$$
$$\theta = 1.95°$$

$$\text{Descent Gradient} = \frac{(980 - (453 + 46))}{1.5}$$
$$\text{Descent Gradient} = 321 \text{ ft / NM}$$
$$\text{Tan}(\theta) = \frac{321}{6076.11548}$$
$$\theta = 3.02°$$

Figure 14-10. DESCENT GRADIENT AND ANGLE, Par 252c(2).

d. Circling Approaches. The maximum descent angle is calculated using the difference between the FAF/stepdown altitude and stepdown/lowest circling minimum descent altitude (CMDA) as appropriate (see figure 14-11).

$$\text{FAF Altitude} = \text{CMDA} + (318 \times \text{Seg. Len. in NM})$$



To calculate FAF altitude for a given descent gradient:
$$2840.04 = 1320 + (318 \times 4.78)$$

Figure 14-11, FAF NET GIVEN SEGMENT LENGTH, Par 252d.

To calculate Descent Gradient and Angle given a FAF altitude and final length:
$$\text{Descent Gradient} = \frac{(2900 - 1320)}{4.78}$$
$$\text{Descent Gradient} = 331$$
$$\text{Tan}(\theta) = \frac{331}{6076.11548}$$
$$\theta = 3.12°$$

253. VISUAL DESCENT POINT (VDP). (Applicable to straight-in procedures only). When dual minimums are published, use the lowest minimum descent altitude (MDA) to calculate the VDP distance. **PUBLISH A VDP FOR ALL STRAIGHT-IN NON-PRECISION APPROACHES** except as follows:

- Do not publish a VDP for locations serviced by part-time or full time remote altimeter settings.

- Do not publish a VDP if the path passes below a required altitude at a stepdown fix.

- If the VDP is between the MAP and the runway, do not publish a VDP.

a. For runways served by a (VGSI), establish the distance from THR to a point where the lowest published VGSI glide slope angle reaches an altitude equal to the MDA. Use the following formula:

$$\text{VDP Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\text{Tan}(\text{VGSI Angle})}$$

- If the difference between the calculated descent angle (paragraph 252) and the VGSI angle is greater than ±0.20°, do not publish a VDP.

b. For runways NOT served by a VGSI, establish the distance from THR to a point where the greater of a three degree or the final segment descent angle reaches the MDA. Use the following formula:

$$\textit{VDP}\ \text{Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\text{Tan}(^{*}\ \text{Angle})}$$

* final segment descent angle or 3°, whichever is higher.

c. Marking VDP Location.

(1) For Non-RNAV SIAP's, mark the VDP location as a DME fix. If DME is not available, do not establish a VDP. Maximum fix error is $\pm$ 0.5 NM.

(2) For RNAV SIAP's, mark the VDP location as an along track distance (ATD) fix to the MAP. Maximum fix error is ± 0.5 NM.

(3) If the final course is not aligned with the runway centerline, use the THR as a vertex, swing an arc of a radius equal to the VDP distance across the final approach course (see figure 14-12). The point of intersection is the VDP. (For RNAV procedures, the distance from the point of intersection to the MAP is the ATD for the VDP.)

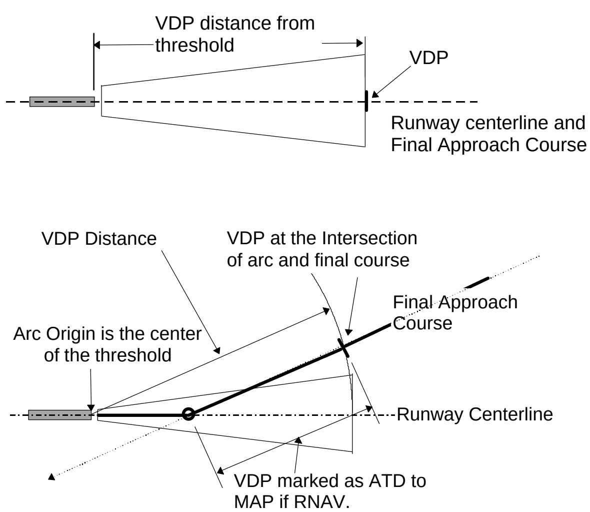


Figure 14-12. VDP LOCATION, Par 253c(3).

254.-259. RESERVED

SECTION 6. CIRCLING APPROACH

260. CIRCLING APPROACH AREA. This is the obstacle clearance area which shall be considered for aircraft maneuvering to land on a runway which is not aligned with the FAC of the approach procedure.

a. Alignment and Area. The size of the circling area varies with the approach category of the aircraft, as shown in table 4. To define the limits of the circling area for the appropriate category, draw an arc of suitable radius from the center of the end of each usable runway. Join the extremities of the adjacent arcs with lines drawn tangent to the arcs. The area thus enclosed is the circling approach area (see figure 15).

Table 4. CIRCLING APPROACH AREA RADII. Par 260a.

Approach Category	Radius (Miles)
A	1.3
B	1.5
C	1.7
D	2.3
E	4.5

Radii ®. Defining size of areas vary with the approach category

Figure 15. CONSTRUCTION OF CIRCLING APPROACH AREA. Par 260a.

b. Obstacle Clearance. A minimum of 300 feet of obstacle clearance shall be provided in the circling approach area. There is no secondary obstacle clearance area for the circling approach (see paragraph 322).

261. CIRCLING APPROACH AREA NOT CONSIDERED FOR OBSTACLE CLEARANCE. It will be permissible to eliminate from consideration a particular sector where prominent obstacles exist in the circling approach area, provided the landing can be made without maneuvering over this sector and further provided that a note to this effect is included in the procedure. Sectors within which circling is not permitted should be identified with runway centerlines, and where necessary, illumination of certain runway lights may be required. Circling restrictions shall be noted on the procedure.

262.-269. RESERVED.

SECTION 7. MISSED APPROACH.

270. MISSED APPROACH SEGMENT. (See ILS and PAR chapters for special provisions). A missed approach procedure shall be established for each IAP. The missed approach shall be initiated at the decision height (DH) or MAP in nonprecision approaches. The missed approach procedure must be simple, specify an altitude, and a clearance limit. The missed approach altitude specified in the procedure shall be sufficient to permit holding or en route flight. Design alternate missed approach procedures using the criteria in this section. The area considered for obstacles has a width equal to that of the final approach area at the MAP and expands uniformly to the width of the initial approach segment at a point 15 flying miles from the MAP. When PCG is available, a secondary area for the reduction of obstacle clearance is identified within the missed approach area which has the same width as the final approach secondary area at the MAP, and which expands uniformly to a width of 2 miles at a point 15 miles from the MAP (see figure 16). Where PCG is not available beyond this point, expansion of the area continues until PCG is achieved or segment terminates. Where PCG is available beyond this point, the area tapers at a rate of 30° inward relative to the course until it reaches initial segment width.

NOTE: Only the primary missed approach procedure shall be included on the published chart.

271. MISSED APPROACH ALIGNMENT. Wherever practical, the missed approach course should be a continuation of the FAC. Turns are permitted, but should be minimized in the interest of safety and simplicity.

272. MAP. The MAP specified in the procedure may be the point of intersection of an electronic glidepath with a DH, a navigation facility, a fix, or a specified distance from the FAF. The specified distance may not be more than the distance from the FAF to the usable landing surface. The MAP shall **NOT** be located prior to the VDP. Specified criteria for the MAP are contained in the appropriate facility chapters.

273. STRAIGHT MISSED APPROACH AREA. When the missed approach course is within 15° of the final approach course, it is considered a straight missed approach (see figure 16). The area considered for obstacle evaluation is specified in paragraph 270.

Figure 16. STRAIGHT MISSED APPROACH AREA. Par 270 and 273.

274. STRAIGHT MISSED APPROACH OBSTACLE CLEARANCE. Within the primary missed approach area, no obstacle shall penetrate the missed approach surface. This surface begins over the MAP at a height determined by subtracting the required final approach ROC and any minimums adjustments, per paragraph 323 from the MDA. It ascends uniformly at the rate of 1 foot vertically for each 40 feet horizontally (40:1). See figure 17. Where the 40:1 surface reaches a height of 1,000 feet below the missed approach altitude (paragraph 270), further application of the surface is not required. In the secondary area, no obstacle may penetrate a 12:1 slope which extends outward and upward from the 40:1 surface at the inner boundaries of the secondary area. See figure 18. Evaluate the missed approach segment to insure obstacle clearance is provided.

a. Evaluate the 40:1 surface from the MAP to the clearance limit (end of the missed approach segment). The height of the missed approach surface over an obstacle is determined by measuring the straight-line distance from the obstacle to the nearest point on the line defining the origin of the 40:1 surface. If obstacles penetrate the surface, take action to eliminate the penetration.

b. The preliminary charted missed approach altitude is the highest of the minimum missed approach obstruction altitude, minimum holding altitude (MHA) established IAW paragraph 293a, or the lowest airway minimum en route altitude (MEA) at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred foot value.

c. Determine if a climbing in holding pattern (climb-in-hold) evaluation is required (see paragraph 293b).

(1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. Compute the 40:1 rise from a point on the line defining the origin of the 40:1 surface in the shortest distance and perpendicular to the end-of-segment line at the clearance limit.

(2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

(3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

(a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

(b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation **IS** required. FAA Order 7130.3, Holding Pattern Criteria, paragraph 35, specifies higher speed groups and, therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under TERPS, paragraph 293a. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in paragraph 35. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

d. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under paragraph 274c(3)(b).

Figure 17. STRAIGHT MISSED APPROACH OBSTACLE CLEARANCE. Par 274.

Figure 18. MISSED APPROACH CROSS SECTION. Par 274.

275. TURNING MISSED APPROACH AREA. (See ILS and PAR chapters for special provisions). If a turn of more than 15° from the FAC is required, a turning missed approach area must be constructed.

a. The dimensions and shape of this area are affected by three variables:

(1) Width of final approach area at the MAP.

(2) All categories of aircraft authorized to use the procedure.

(3) Number of degrees of turn required by the procedure.

b. Secondary areas for the reduction of obstacle clearance are permitted when PCG is provided. The secondary area begins where a line perpendicular to the straight flightpath, originating at the point of completion of the turn, intersects the outer boundaries of the missed approach segment. The width of the secondary area expands uniformly from zero to 2 miles at 15 NM flight track point.

c. Primary areas. Figures 19, 20, 21, 22, 23, and 24 show the manner of construction of some typical turning missed approach areas. The following radii are used in the construction of these areas:

(1) 90° Turn or Less. Narrow Final Approach Area at MAP. See figure 19. To construct the area:

Figure 19. TURNING MISSED APPROACH AREA. 90° Turn or Less. Narrow Final Approach Area at MAP. Par 275c(1).

(a) Draw an arc with the radius (R_1) from the MAP. This line is then extended outward to a point 15 miles from the MAP, measured along the line. This is the assumed flightpath (see table 5).

Table 5. TURNING MISSED APPROACH RADII (Miles). Par 275.

Approach Category	Obstacle Clearance Radius (R)	Flightpath Radius (R_1)
A	**2.6**	**1.30**
B	**2.8**	**1.40**
C	**3.0**	**1.50**
D	**3.5**	**1.75**
E	**5.0**	**2.50**

(b) Establish points "A_2" and "B_1" measuring 6 miles perpendicular to the flightpath at the 15 mile point.

(c) Now connect "A_2" and "B_1" with a straight line.

(d) Draw an arc with the radius (R) from point "A" to "A_1". This is the edge of the obstacle clearance area.

(e) Establish point "B" by measuring backward on the edge of the final approach area a distance of 1 mile or a distance equal to the fix error PRIOR to the FAF, whichever is greater.

(f) Connect points "A_1" and "A_2", and points "B" and "B_1" with straight lines.

(2) 90° Turn or Less. Wide Final Approach Area at MAP. See figure 20. To construct the area:

Figure 20. TURNING MISSED APPROACH AREA. 90° Turn or Less. Wide Final Approach Area at MAP. Par 275c(2)

(a) Draw an arc with the appropriate radius (R_1) from the MAP. This line is then extended outward to a point 15 miles from the MAP, measured along the line. This is the assumed flightpath.

(b) Establish points "A_2" and "B_1" by measuring 6 miles perpendicular to the flightpath at the 15-mile point.

(c) Now connect "A_2" and "B_1" with a straight line.

(d) Draw an arc with the appropriate radius (R) from point "A" to point "A_1". This is the edge of the obstacle clearance area.

(e) Establish point "B" by measuring backward on the edge of the final approach area a distance of 1 mile or a distance equal to the fix error PRIOR to the FAF, whichever is greater.

(f) Connect points "A_1" and "A_2", and points "B" and "B_1" with straight lines.

(3) More Than 90° Turn. Narrow Final Approach Area at MAP (see figure 21). To construct the area:

Figure 21. TURNING MISSED APPROACH AREA. More Than 90° Turn. Narrow Final Approach Area at MAP. Par 275c(3).

(a) Draw an arc with the radius (R_1) from the MAP through the required number of degrees and then continue outward to a point 15 miles from the MAP, measured along this line, which is the assumed flightpath.

(b) Establish points "A_2" and "C_1" by measuring 6 miles on each side of the assumed flightpath and perpendicular to it at the 15-mile point.

(c) Now connect points "A_2" and "C_1" with a straight line.

(d) Draw an arc with the radius (R) from point "A" to point "A_1" (figure 21 uses 135º). This is the outer edge of the obstacle clearance area.

(e) Locate point "C" at the inner edge of the final approach secondary area opposite the MAP. (Point "A" and point "C" will be coincident when the MAP is the facility.)

(f) Connect points "A_1" and "A_2", and points "C" and "C_1" with straight lines.

(4) More than 90° Turn. *Wide Final* Approach Area at MAP (see figure 22). To construct the area:

Figure 22. TURNING MISSED APPROACH AREA. More Than 90° Turn. Wide Final Approach Area at MAP. Par 275c(4).

(a) Draw the assumed flightpath arc with the radius (R_1) from the MAP the required number of degrees to the desired flightpath or course.

(b) Establish points "A_4" and "C_1" by measuring 6 miles on each side of the assumed flightpath and perpendicular to it at the 15-mile point.

(c) Connect points "A_4" and "C_1" with straight lines.

(d) Draw a 90° arc with the appropriate radius (R) from point "A" to "A_1". Note that when the width of the final approach area at the MAP is greater than the appropriate radius (R), the turn is made in two increments when constructing the obstacle clearance area.

(e) Draw an arc with the radius (R) from point "D" (edge of final approach secondary area opposite MAP) the required number of degrees from point "A_2" to point "A_3". Compute the number of degrees by subtracting 90° from the total turn magnitude.

(f) Connect points "A_1" and "A_2", with a straight line.

(g) Locate point "C" at the inner edge of the final approach secondary area opposite the MAP.

(h) Connect point "A_3" with point "A_4", and connect point "C" with point "C_1" using straight lines.

(5) 180° Turn. Narrow Final Approach Area at MAP (see figure 23). To construct the area:

Figure 23. TURNING MISSED APPROACH AREA. 180° Turn. Narrow Final Approach Area at MAP. Par 275c(5).

(a) Draw an arc with the radius (R_1) from the MAP through 180°, and then continue outward to a point 15 miles from the MAP, measured along this line, which is the assumed flightpath.

(b) Establish points "A_2" and "C_2" by measuring 6 miles on each side of the assumed flightpath, and perpendicular to it at the 15-mile point.

(c) Now connect points "A_2" and "C_2" with a straight line.

(d) Locate point "C" at the inner edge of the final approach secondary area opposite the MAP. (Point "A" and point "C" will be coincident when the MAP is the facility.)

(e) Draw an arc with the radius (R) from point "A" to point "A_1" (180°). This is the outer edge of the obstacle clearance area.

(f) Connect points "A_1" and "A_2", and points "C" and "C_1" by straight lines. (The line "A_1-A_2" joins the arc tangentially).

(6) 180° Turn. Wide Final Approach Area at MAP (see figure 24). To construct the area:

Figure 24. TURNING MISSED APPROACH AREA. 180° Turn. Wide Final Approach Area at MAP. Par 275c(6).

(a) Draw the flightpath arc with radius (R_1) from the MAP and then continue the line outward to a point 15 miles from the MAP, measured along the assumed flightpath.

(b) Establish points "A_4" and "C_1" by measuring 6 miles on each side of the flightpath and perpendicular to it at the 15-mile point.

(c) Now connect "A_4" and "C_1" with a straight line.

(d) Draw a 90° arc with the appropriate radius (R) from point "A" to "A_1". Note that when the width of the final approach area at the MAP is greater than the appropriate radius (R), the turn is made in two increments when constructing the obstacle clearance area.

(e) Draw an arc with the radius (R) from point "D" (edge of final approach secondary area opposite MAP) the required number of degrees from point "A_2" to point "A_3". Compute the number of degrees by subtracting 90° from the total turn magnitude.

(f) Connect points "A_1" and "A_2", with a straight line.

(g) Locate point "C" at the inner edge of the final approach secondary area opposite the MAP.

(h) Connect points "A_3" and "A_4", and points "C" and "C_1"with straight lines. (The line "A_3-A_4" joins the arc tangentially).

276. TURNING MISSED APPROACH OBSTACLE CLEARANCE. The methods of determining the height of the 40:1 missed approach surface over obstacles in the turning missed approach area vary with the amount of turn involved. Evaluate the missed approach segment to ensure the 40:1 OIS is not penetrated.

a. 90° Turn or Less. See figure 25. Zone 1 is a 1.6 mile continuation of the final approach secondary area, and has identical obstacle clearance requirements. Zone 2 is the area in which the height of the missed approach surface over an obstacle must be determined. To do this, first identify line "A-D-B". Point "B" is located by measuring backward on the edge of the final approach area a distance of 1 mile or a distance equal to the fix error prior to the FAF, whichever is greater. This is to safeguard the short-turning aircraft. Thus, the height of the missed approach surface over an obstacle in zone 2 is determined by measuring the straight-line distance from the obstacle to the nearest point on line "A-D-B" and computing the height based on the 40:1 ratio. The height of the missed approach surface over the MAP is the same as specified in paragraph 274. When an obstacle is in a secondary area, measure the straight-line distance from the nearest point on the line "A-D-B" to the point on the inner edge of the secondary area which is nearest the obstacle. Compute the height of the missed approach surface at this point, using the 40:1 ratio. Then apply the 12:1 secondary area ratio from the height of the surface for the remaining distance to the obstacle.

Figure 25. TURNING MISSED APPROACH OBSTACLE CLEARANCE. 90° Turn or Less. Par 276a.

b. More Than 90° Turn. See figure 26. In this case a third zone becomes necessary. Zone 3 is defined by extending a line from point "B" to the extremity of the missed approach area perpendicular to the FAC. Zone 3 will encompass all of the missed approach area not specifically within zones 1 and 2. All distance measurements in zone 3 are made from point "B". Thus the height of the missed approach surface over an obstacle in zone 3 is determined by measuring the distance from the obstacle to point "B" and computing the height based on the 40:1 ratio. The height of the missed approach surface over point "B" for zone 3 computations is the same as the height of the MDA. For an obstacle in the secondary area, use the same measuring method prescribed in paragraph 276a, except that the original measuring point shall be point "B."

Figure 26. TURNING MISSED APPROACH OBSTACLE CLEARANCE. More Than a 90° Turn. Par 276b.

c. Secondary Area. In the secondary area no obstacles may penetrate a 12:1 slope which extends outward and upward from the 40:1 surface from the inner to the outer boundary lines of the secondary area.

d. Evaluate the missed approach segment from the MAP to the clearance limit. Terminate the 40:1 obstacle clearance surface (OCS) at an elevation corresponding to the en route ROC below the missed altitude.

(1) If the 40:1 OCS terminates prior to the clearance limit, continue the evaluation using a level OIS at the height that the 40:1 OCS was terminated.

(2) If the clearance limit is reached before the 40:1 OCS terminates, continue a climb-in-hold evaluation at the clearance limit.

e. The preliminary charted missed approach altitude is the highest of the minimum missed approach obstruction altitude, MHA established IAW paragraph 293a, or the lowest airway MEA at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred foot value.

f. Determine if a climb-in-hold evaluation is required (see paragraph 293b).

(1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. Compute the 40:1 rise from a point on the "A-D-B" line in the shortest distance to the end-of-segment line at the clearance limit.

(2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

(3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

(a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

(b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation IS required. FAA Order 7130.3, Holding Pattern Criteria, paragraph 35, specifies higher speed groups, and, therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under TERPS paragraph 293a. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in paragraph 35. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

g. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under paragraph 274c(3)(b).

277. COMBINATION STRAIGHT AND TURNING MISSED APPROACH AREA. If a straight climb to a specific altitude followed by a turn is necessary to avoid obstacles, a combination straight and turning missed approach area must be constructed. The straight portion of this missed approach area is section 1. The portion in which the turn is made is section 2. Evaluate the missed approach segment to ensure obstacle clearance is provided.

a. Straight Portion. Section 1 is a portion of the normal straight missed approach area and is constructed as specified in paragraph 273. Obstacle clearance is provided as specified in paragraph 274 except that secondary area reductions do not apply. The length of section 1 is determined as shown in figure 27 and relates to the need to climb to a specified altitude prior to commencing the turn. Point A_1 marks the end of section 1. Point B_1 is one mile from the end of section 1 (see figure 27).

b. Turning Portion. Section 2 is constructed as specified in paragraph 275 except that it begins at the end of section 1 instead of at the MAP. To determine the height which must be attained before commencing the missed approach turn, first identify the controlling obstacle on the side of section 1 to which the turn is to be made. Then measure the distance from this obstacle to the nearest edge of the section 1 area. Using this distance as illustrated in figure 27, determine the height of the 40:1 slope at the edge of section 1. This height plus 250 feet (rounded off to the next higher 20-foot increment) is the height at which the turn should be started. Obstacle clearance requirements in section 2 are the same as those specified in paragraph 276 except that zone 1 is not considered and section 2 is expanded to start at point "B" if no fix exists at the end of section 1, or if no course guidance is provided in section 2 (see figure 27).

c. Evaluate the 40:1 surface from the MAP to the clearance limit (end of the missed approach segment). If obstacles penetrate the surface, take action to eliminate the penetration.

d. The preliminary charted missed approach altitude is the lowest of the minimum missed approach obstruction altitude, MHA established IAW paragraph 293a, or the lowest airway MEA at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred foot value.

Figure 27. COMBINATION MISSED APPROACH AREA. Par 277(a)

e. Determine if a climb-in-hold evaluation is required (see paragraph 293b).

(1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. First, compute the 40:1 rise from a point on the line defining the origin of the 40:1 surface at the MAP, in the shortest distance and perpendicular to the end-of-section 1 segment. If there is a remote altimeter setting source (RASS) and the missed approach instructions do not include a parenthetical climb to altitude then the elevation at the end of section 1 is adjusted by subtracting the altitude difference between the RASS adjustments when two remote altimeter sources are used; or subtracting the RASS adjustment for a part-time altimeter source. The resulting altitude at the end of section 1 shall not be lower than the 40:1 surface height at the MAP. Second, compute the 40:1 rise from a point on the nearest edge of section 1, in the shortest distance to the end-of-segment line at the clearance limit. Add the two values together and this is the 40:1 surface height at the end of the segment (clearance limit).

(2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

(3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

(a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

(b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation IS required. FAA Order 7130.3, paragraph 35, specifies higher speed groups and therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under TERPS paragraph 293a. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in paragraph 35. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

f. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under paragraph 274c(3)(b).

278. END OF MISSED APPROACH. Aircraft shall be assumed to be in the initial approach or en route environment upon reaching minimum obstacle clearance altitude (MOCA) or MEA. Thereafter, the initial approach or the en route clearance criteria apply.

279. RESERVED.

SECTION 8. TERMINAL AREA FIXES

280. GENERAL. Terminal area fixes include, but are not limited to the FAF, the IF, the IAF, the holding fix, and when possible, a fix to mark the MAP. Each fix is a geographical position on a defined course. Terminal area fixes should be based on similar navigation systems. For example, TACAN, omni-directional radio range tactical air navigation (VORTAC), and VOR/DME facilities provide radial/DME fixes. NDB facilities provide bearings. VOR facilities provide VOR radial. The use of integrated (VHF/NDB) fixes shall be limited to those intersection fixes where no satisfactory alternative exists.

281. FIXES FORMED BY INTERSECTION. A geographical position can be determined by the intersection of courses or radials from two stations. One station provides the course the aircraft is flying and the other provides a crossing indication which identifies a point along the course which is being flown. Because all stations have accuracy limitations, the geographical point which is identified is not precise, but may be anywhere within a quadrangle which surrounds the plotted point of intersection. Figure 28 illustrates the intersection of an arc and a radial from the same DME facility and the intersection of two radials or courses from different navigation facilities. The area encompassed by the sides of the quadrangle formed in these ways is referred to in this publication as the "fix displacement area".

282. COURSE/DISTANCE FIXES.

***a.* A DME fix is formed by a DME reading** on a positive navigational course. The information should be derived from a single facility with collocated azimuth and DME antennas. Collocation parameters are defined in FAA Order 6050.32, Spectrum Management Regulations and Procedures. However, when a unique operational requirement indicates a need for DME information from other than collocated facilities, an individual IAP which specifies DME may be approved, provided the angular divergence between the signal sources at the fix does not exceed 23° (see figure 28). For limitation on use of DME with ILS, see paragraph 912.

b. ATD Fixes. An ATD fix is an along track position defined as a distance in NM, with reference to the next WP along a specified course.

Figure 28. INTERSECTION FIX DISPLACEMENT. Par 281 and 282a

283. FIXES FORMED BY RADAR. Where ATC can provide the service, Airport Surveillance Radar (ASR) may be used for any terminal area fix. PAR may be used to form any fix within the radar coverage of the PAR system. Air Route Surveillance Radar (ARSR) may be used for initial approach and intermediate approach fixes.

284. FIX DISPLACEMENT AREA. The areas portrayed in figure 28 extend along the flight course from point "A" to point "C". The fix error is a plus-or-minus value, and is represented by the lengths from "A" to "B" and "B" to "C". Each of these lengths is applied differently. The fix error may cause the fix to be received early (between "A" and "B"). Because the fix may be received early, protection against obstacles must be provided from a line perpendicular to the flight course at point "A".

285. INTERSECTION FIX DISPLACEMENT FACTORS. The intersection fix displacement area is determined by the system use accuracy of the navigation fixing systems (see figure 29). The system use accuracy in VOR and TACAN type systems is determined by the combination of ground station error, airborne receiving system error, and flight technical error (FTE). En route VOR data have shown that the VOR system accuracy along radial 4.5°, 95 percent of occasions, is a realistic, conservative figure. Thus, in normal use of VOR or TACAN intersections, fix displacement factors may conservatively be assessed as follows:

a. Along-Course Accuracy.

(1) VOR/TACAN radials, plus-or-minus 4.5°.

(2) Localizer course, plus-or-minus 1°.

(3) NDB courses or bearing, plus-or-minus 5°.

NOTE: *The plus-or-minus 4.5° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error, the FTE, and the VOR airborne equipment error are controlled to certain normal tolerances. Where it can be shown that any of the three error elements is consistently different from these assumptions (for example, if flight inspection shows a consistently better VOR signal accuracy or stability than the one assumed, or if it can be shown that airborne equipment error is consistently smaller than assumed), VOR fix displacement factors smaller than those shown above may be utilized under paragraph 141.*

b. Crossing Course Accuracy.

(1) VOR/TACAN radials, plus-or-minus 3.6°.

(2) Localizer course, plus-or-minus 0.5°.

(3) NDB bearings, plus-or-minus 5°.

NOTE: The plus-or-minus 3.6° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error and the VOR airborne equipment error are controlled to certain normal tolerances. Since the crossing course is not flown, FTE is not a contributing element. Where it can be shown that either of the error elements is consistently different, VOR displacement factors smaller than those shown above may be utilized IAW paragraph 141.

286. OTHER FIX DISPLACEMENT FACTORS.

a. Radar. Plus-or-minus 500 feet or 3 percent of the distance to the antenna, whichever is greater.

b. DME. Plus-or-minus 1/2 (0.5) miles or 3 percent of the distance to the antenna, whichever is greater.

c. 75 MHz Marker Beacon.

(1) Normal powered fan marker, plus-or-minus 2 miles.

(2) Bone-shaped fan marker, plus-or-minus 1 mile.

(3) Low powered fan marker, plus-or-minus 1/2 mile.

(4) "Z" marker, plus-or-minus 1/2 mile.

NOTE: Where these 75 MHz marker values are restrictive, the actual coverage of the fan marker (2 milliamp signal level) at the specific location and altitude may be used instead.

d. Overheading a Station. The fix error involved in station passage is not considered significant in terminal applications. The fix is therefore considered to be at the plotted position of the navigation facility. The use of TACAN station passage as a fix is **NOT** acceptable for holding fixes or high altitude IAF's.

287. SATISFACTORY FIXES.

a. Intermediate, Initial, or Feeder Fix. To be satisfactory as an intermediate, initial, or feeder approach fix, the fix error must not be larger than 50 percent of the appropriate segment distance which follows the fix. Measurements are made from the plotted fix position (see figure 29).

Figure 29. INTERMEDIATE, INITIAL, OR FEEDER APPROACH FIX ERRORS. Par 287.

b. Holding Fixes. Any terminal area fix except overheading a TACAN may be used for holding. The following conditions shall exist when the fix is an intersection formed by courses or radials:

(1) The angle of divergence of the intersecting courses or radials shall not be less than 45°.

(2) If the facility which provides the crossing courses is NOT an NDB, it may be as much as 45 miles from the point of intersection.

(3) If the facility which provides the crossing course is an NDB, it must be within 30 miles of the intersection point.

(4) If distances stated in paragraphs 287b(2) or (3) are exceeded, the minimum angle of divergence of the intersecting courses must be increased at the following rate:

(a) If an NDB facility is involved, 1° for each mile over 30 miles.

(b) If an NDB facility is NOT involved, 1/2° for each mile over 45 miles.

For example, if the intersection is formed by radials from VOR's 30 and 45 miles away, the minimum angle is 45°. If one of the facilities is NDB, the minimum angle is 60° (see figure 30).

Figure 30. MINIMUM DIVERGENCE ANGLE FOR HOLDING FIXES. Par 287b(4)(b)

c. FAF. For a fix to be satisfactory for use as a FAF, the fix error should not exceed plus-or-minus 1 mile (see figures 31-1 and 31-2). It may be as large as plus-or-minus 2 miles when:

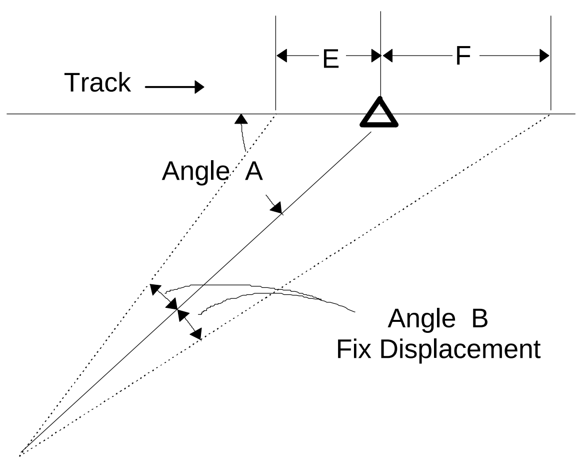
(1) The MAP is marked by overheading an air navigation facility (except 75 MHz markers); OR

(2) A buffer of equal length to the excessive fix error is provided between the published MAP and the point where the missed approach surface begins (see figure 32).

Figure 32. FAF ERROR BUFFER. Par 287c(2).

Figure 31-1. MEASUREMENT OF FAF ERROR. Par 287c

Calculate fix displacement using the following formulas:



Formula *Example*

$$E = \frac{6076.11548 \times D \times Sin\ B}{Sin\left(A + B\right)} \qquad E = \frac{6076.11548 \times 30 \times Sin\ 4.5°}{Sin\left(50 + 4.5°\right)}$$

$$\frac{14301.80}{0.81411} = 17567.62$$

$$F = \frac{6076.11548 \times D \times Sin\ B}{Sin\left(A - B\right)} \qquad F = \frac{6076.11548 \times 30 \times Sin\ 4.5°}{Sin\left(50° - 4.5°\right)}$$

$$\frac{14301.80}{0.71325} = 20051.59$$

Figure 31-2. FIX DISPLACEMENT CALCULATIONS. Par 287c.

288. USING FIXES FOR DESCENT.

a. Distance Available for Descent. When applying descent gradient criteria applicable to an approach segment (initial, intermediate or final approach areas), the measuring point is the plotted position of the fix (see figure 33).

Figure 33. DISTANCE FOR DESCENT GRADIENT APPLICATION. Par 288a.

b. Obstacle Clearance After Passing a Fix. It is assumed that descent will begin at the earliest point the fix can be received. Full obstacle clearance shall be provided from this point to the plotted point of the next fix. Therefore, the altitude to which descent is to be made at the fix must provide the same clearance over obstacles in the fix displacement area as it does over those in the approach segment which is being entered (see figures 34-1 and 34-2).

Figure 34-1. OBSTACLE CLEARANCE AREA BETWEEN FIXES. Par 288b.

Figure 34-2. CONSTRUCTION OF FIX DISPLACEMENT AREA FOR OBSTACLE CLEARANCE. Par 288b.

c. Stepdown Fixes. See figure 35.

(1) DME, Along Track Distance (ATD) or Radar Fixes. Except in the intermediate segment within a procedure turn (paragraph 244), there is no maximum number of stepdown fixes in any segment when DME, an ATD fix, or radar is used. DME and ATD fixes may be denoted in tenths of a mile. The distance between fixes shall not be less than 1 mile.

(2) Intersection Fixes.

(a) Only one stepdown fix is permitted in the final and intermediate segments.

(b) If an intersection fix forms a FAF, IF, or IAF:

1 The same crossing facility shall be used for the stepdown fix(es) within that segment.

2 All fixes from the IF to the last stepdown fix in final shall be formed using the same crossing facility.

(c) Table 5A shall be used to determine the number of stepdown fixes permitted in the initial segment. The distance between fixes shall not be less than 1 mile.

(3) Altitude at the Fix. The minimum altitude at each stepdown fix shall be specified in 100-foot increments, except the altitude at the last stepdown fix in the final segment may be specified in a 20-foot increment.

(4) In the Final Segment:

(a) A stepdown fix shall not be established unless a decrease of at least 60 feet in MDA or a reduction in visibility minimums is achieved.

(b) The last stepdown fix error shall not exceed plus-or-minus 2 NM or the distance to the MAP, whichever is less. The fix error for other stepdown fixes in final shall not exceed 1 NM.

(c) Minimums shall be published both with and without the last stepdown fix, except for procedures requiring DME or NDB procedures which use a VOR radial to define the stepdown fix.

Figure 35. FINAL SEGMENT STEPDOWN FIX. Par 288c.

Table 5A. STEPDOWN FIXES IN INITIAL SEGMENT. Par 288c(2)(c).

Length of Segment	Number of Fixes
5-10 NM	1 stepdown fix
over 10-15 NM	2 stepdown fixes
over 15 NM	3 stepdown fixes

289. OBSTACLES CLOSE TO A FINAL APPROACH OR STEPDOWN FIX. Existing obstacles close to the FAF/stepdown fix may be eliminated from consideration if the following conditions are met:

a. The obstacle is in the final approach trapezoid within 1 NM past the point the FAF/stepdown fix can first be received, and...

b. The obstacle does not penetrate a 7:1 obstacle identification surface (OIS). The surface begins at the earliest point the fix can be received and extends toward the MAP 1 NM. The beginning surface height is determined by subtracting the final segment ROC (and adjustments from paragraphs 323a, b, or c, as applicable) from the minimum altitude required at the fix. The surface slopes downward 1 foot vertically for each 7 feet horizontally toward the MAP.

c. Obstacles eliminated from consideration by application of this paragraph shall be noted on the procedure.

d. The following formulas may be used to determine the OIS height at the obstacle or the minimum fix altitude based on applying the surface to an obstacle which must be eliminated.

Fix Alt = MSL altitude at the fix (round up IAW 288c.(3).)
Obst Dist = Distance from earliest fix reception to obstacle
ROC = Required Obstacle Clearance + adjustments
Obst Elev = MSL obstacle elevation

$$\text{OIS height} = FixAlt - ROC - \left[\frac{Obst\ Dist}{7}\right]$$

$$\text{MinFixAlt} = ObstElev + ROC + \left[\frac{Obst\ Dist}{7}\right]$$

See figure 36. To determine fix error, see paragraphs 284, 285, and 286.

FIGURE 36. OBSTACLES CLOSE-IN TO A FIX. Par 289.

SECTION 9. HOLDING

290. HOLDING PATTERNS. Criteria for holding pattern airspace are contained in FAA Order 7130.3, and provide for separation of aircraft from aircraft. The criteria contained herein deal with the clearance of holding aircraft from obstacles.

291. ALIGNMENT. Whenever practical, holding patterns should be aligned to coincide with the flight course to be flown after leaving the holding fix. However, when the flightpath to be flown is along an arc, the holding pattern should be aligned on a radial. When a holding pattern is established at a FAF and a PT is not used, the inbound course of the holding pattern shall be aligned to coincide with the FAC unless the FAF is a facility. When the FAF is a facility, the inbound holding course and the FAC shall not differ by more than 30°.

292. AREA.

a. The primary obstacle clearance area shall be based on the appropriate holding pattern area specified in FAA Order 7130.3.

b. No reduction in the pattern sizes for 'on-entry' procedures is permitted.

c. Pattern number 4 is the minimum size authorized.

d. When holding is at an intersection or RNAV fix, the selected pattern shall be large enough to contain at least 3 corners of the fix displacement area. See paragraphs 284 and 285 and figure 37-1.

e. When paragraph 293b is used, the primary holding area shall encompass the departure or missed approach segment width at the holding fix (see figure 37-2).

f. A secondary area 2 miles wide surrounds the perimeter of the primary area

FIGURE 37-1. HOLDING PATTERN TEMPLATE APPLICATION. Par 292.

293. OBSTACLE CLEARANCE.

a. Level Holding. A minimum of 1,000 feet of obstacle clearance shall be provided throughout the primary area. In the secondary area 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. For computation of obstacle clearance in the secondary area see paragraph 232c. Allowance for precipitous terrain should be considered as stated in paragraph 323a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet. See paragraph 231.

b. Climbing in a Holding Pattern. When a climb in hold is used, as in a departure or missed approach, no obstacle shall penetrate the holding surface. This surface begins at the end of the segment leading to the holding fix. Its elevation is that of the departure OIS or missed approach surface at the holding fix. It rises at a 40:1 rate to the edge of the primary area, then at a 12:1 rate to the outer edge of the secondary area. The distance to any obstacle is measured from the obstacle to the nearest point on the end of the segment at the holding fix. See figure 37-2 and FAA Order 7130.3, paragraph 35.

FIGURE 37-2. CLIMBING IN A HOLDING PATTERN. Par 293b.

294. - 299. RESERVED.

Table 6. EFFECT OF HAT/HAA ON VISIBILITY MINIMUMS

HAT/HAA (ft.)	250-320	321-390	391-460	461-530	531-600	601-670	671-740	741-810	811-880	881-950	951 & above
CAT A	1 mi --									1¼-	
CAT B	1 mi--							1¼--			1½
HAT/HAA	250-400		401-500		501-600	601-670	671-740	741-810	811-880	881-950	951 & above
CAT C	1 mi		1¼		1½	1¾	2	2¼	2½	2¾	3
HAT/HAA	250-341	342-426	427-511	512-600		601-670	671-740	741-810	811-880	881-950	951 & above
CAT D	1 mi	1¼	1½	1¾		2	2¼	2½	2¾	3-----------------------	
HAT/HAA	250-320	321-390	391-460	461-530	531-600	601-670	671-740	741-810	811-880	881-950	951 & above
CAT E	1 mi	1¼	1½	1¾	2	2¼	2½	2¾	3--		

c. The minimum visibility prior to applying credit for lights shall be the higher of the following values:

(1) The MAP to threshold distance (where the MAP is reached before the threshold).

(2) Those given in table 6 or 6a, paragraph 331.

This subparagraph does not apply to a procedure where the MAP is more than 2 statute miles from the airport and the procedure is noted, "Fly visual to airport" in which case the required visibility shall be at least 2 miles, but not less than the visibility specified in Table 6.

d. When straight-in minimums are not authorized, only circling MDA's and visibilities will be established. In establishing circling visibility minimums, paragraph 331 applies. These minimums shall be no lower than those specified in paragraph 351.

e. Circling landing minimums shall NOT be lower than straight-in landing minimums.

331. EFFECT OF HAT/HAA AND FACILITY DISTANCE ON STRAIGHT-IN AND CIRCLING VISIBILITY MINIMUMS. The minimum standard visibility required for the pilot to establish visual reference in time to descend safely from the MDA and maneuver to the runway or airport varies with the aircraft category, the HAT/HAA, and the accuracy of the navigation system. Table 6 specifies the minimum standard visibility as determined by HAT/HAA. Table 6A specifies the minimum standard visibility as determined by distance from the facility to the runway.

***NOTE**: The higher of the visibilities derived from the table applies.*

Table 6A. EFFECT OF FACILITY DISTANCE ON VISIBILITY MINIMUMS

NAVAID TYPE	**CAT**	**DISTANCE FROM FACILITY TO MAP OR RWY THLD (whichever is farther)**				
		0-10	**>10-15**	**>15-20**	**>20-25**	**>25-30**
ASR	**A**	1	1	1	N/A	N/A
	B	1	1¼	1¼		
	C	1	1½	1½		
	D-E	1	2	2		
NDB DF	**A**	1	1	N/A	N/A	N/A
	B	1	1¼			
	C	1	1½			
	D-E	1	2			
VOR TACAN LOC SDF LDA	**A**	1	1	1	1	1
	B	1	1	1	1¼	1¼
	C	1	1	1¼	1½	1½
	D-E	1	1¼	1½	1¾	2

332. EFFECT OF OBSTACLES. Visibility minimums must be at or above certain values when obstacles penetrate the visual assessment surfaces. See paragraph 251.

333. RUNWAY VISUAL RANGE (RVR). RVR is a system of measuring the visibility along the runway. It is an instrumentally derived value that represents the horizontal distance a pilot will see down the runway from the approach end. It is based on the sighting of either high intensity runway lights or the visual contrast of other targets, whichever yields the greater visual range.

334. RUNWAY REQUIREMENTS FOR APPROVAL OF RVR. RVR may be authorized for straight-in approach procedures and takeoff when the following requirements are met with respect to the runway to be used.

a. Transmissometers shall be located under standards established by the approval authority (e.g., FAA Standard 008).

b. High intensity runway lights spaced at consecutive intervals of not more than 200 feet shall be operative.

c. Instrument runway markings, or touchdown zone and centerline (TDZ/CL) lighting are required for nonprecision approaches. Precision instrument (all-weather) runway markings or TDZ/CL lighting are required for precision approaches. Where sufficient runway lengths are not available to accommodate standard all-weather markings, the approving authority will determine the runway markings to be used. Where required runway markings are not available and credit for lights is not granted, but TDZ/CL's are available, RVR equal to the visibility minimum without lights is authorized.

335. COMPARABLE VALUES OF RVR AND GROUND VISIBILITY. If RVR minimums for takeoff or landing are prescribed in an instrument approach procedure but RVR is not reported for the runway of intended operation, the RVR minimums shall be converted to ground visibility in accordance with table 7, and observed as the applicable visibility minimum for takeoff or landing on that runway.

Table 7. COMPARABLE VALUES OF RVR AND GROUND VISIBILITY

RVR	VIS (Statute Miles)	RVR	VIS (Statute Miles)
1600	¼	4500	7/8
2400	½	5000	1
3200	5/8	6000	1-1/4
4000	¾		

336.-339. RESERVED.

SECTION 4. VISIBILITY CREDIT FOR LIGHTS

340. GENERAL. Approach lighting systems extend visual cues to the approaching pilot and make the runway environment apparent with less visibility than when such lighting is not available. This section identifies lighting systems and prescribes the operational conditions which must exist in order to reduce straight-in visibility minimums. Table 9 for civil and table 10 for military in paragraph 350 specify the **LOWEST** visibility minimums which can result from application of this section.

341. STANDARD LIGHTING SYSTEMS. Listed in table 8 are the types of standard lighting systems and the required operational coverage for each type.

342. OPERATIONAL CONDITIONS. Credit to reduce straight-in landing minimums for standard or equivalent approach light systems may be given when the following conditions exist for the straight-in landing runway:

a. Markings. The runway must have nonprecision instrument or precision instrument (all-weather) markings or TDZ/CL's as specified in paragraph 334c, and in the directives of the appropriate approving authority.

b. Approach Course. The final approach course must place the aircraft within the operational coverage of the lighting system at a distance from the landing threshold equal to the standard visibility required without lights. See paragraph 330 and figure 37D for guidance.

Table 8. STANDARD LIGHTING SYSTEMS

ABBREV. IFR	LIGHTING SYSTEM	Oper. Coverage (Degrees) Lateral (±)	Vertical (abv Hor.)
ALSF-I	Standard approach light system with sequenced flashers	21.0* 12.5#	12.0* 12.5#
ALSF-II	Standard approach light system with sequenced flashers & CAT II mod.	21.0* 12.5#	12.0* 12.5#
SSALS	Simplified short approach light system	21.0	12.0
SSALF	Simplified short approach light system with sequenced flashers	21.0* 12.5#	12.0* 12.5#
SSALR	Simplified short approach light system with runway alignment indicator lights	21.0* 12.5#	12.0* 12.5#
MALS	Medium intensity approach light system	10.0	10.0*
MALSF	Medium intensity approach light system with sequenced flashers	10.0* 12.5#	10.0* 12.5#
MALSR	Medium intensity approach light system with runway alignment indicator lights	10.0* 12.5#	10.0* 12.5#
ODALS	Omnidirectional approach light system	360#	+2- +10#
VFR			
REIL	Runway end identifier lights	12.5	12.5
LDIN	Lead-in lighting system (can be * or #)	12.5	12.5
VASI	Visual approach slope indicators	10.0	3.5

RUNWAY LIGHT SYSTEMS

HIRL	High intensity runway lights
MIRL	Medium intensity runway lights
LIRL	Low intensity runway lights
TDZ/CL	Touchdown zone and centerline lights

NOTE: *Descriptions of lighting systems may be found in appendix 5 and FAA Order 6850.2.*

**Steady-burning* *#Sequenced flashers*

343. VISIBILITY REDUCTION. Standard visibility requirements are computed by applying the criteria contained in paragraph 331. When the visibility without lights value does not exceed 3 statute miles, these requirements may be reduced by giving credit for standard or equivalent approach light system as follows (see paragraph 341 and appendix 5):

a. **The provisions of paragraphs** 332, 342, 935, or 1025, as appropriate, must be met.

Figure 37D. APPLICATION OF LATERAL COVERAGE ANGLES OF TABLE 8, Par 342b.

NOTE: The final approach course to an 'on-airport' facility transits all approach light operational areas within limits of visibility arc, whereas the final approach course from the 'off-airport' facility may be restricted only to an ALS or SALS for visibility credit.

b. Where the visibility required without lights does not exceed one mile, visibility as low as that specified in the appropriate table in paragraph 350 with associated DH or HAT and lighting may be authorized.

c. For civil application, where the visibility required without lights exceeds 1 mile, a reduction of ½ mile may be made for SSALR, MALSR or ALSF-1/2 provided such visibility minimum is not less than that specified in paragraph 350. Reduction for CAT D aircraft in NDB approach procedures shall not exceed 1/4 mile or result in visibility minimums lower than 1 mile.

d. For military applications, where the visibility required without lights exceeds 1 mile, a reduction of 1/4 mile may be made for SSALS, SALS, MALS, or ODALS, and a reduction of 1/2 mile may be made for ALS, SSALR, or MALSR provided such visibility minimum is not less than that specified in paragraph 350.

e. Where visibility minimums are established in order to see and avoid obstacles, visibility reductions shall not be authorized.

f. Visibility reductions are NOT cumulative.

344. OTHER LIGHTING SYSTEMS. In order for variations of standard systems and other systems not included in this chapter to receive visibility reduction credit, the operational conditions specified in paragraph 342 must be met. Civil airport lighting systems which do not meet known standards or for which criteria do not exist, will be handled UNDER the provisions of paragraph 141. Military lighting systems may be equated to standard systems for reduction of visibility as illustrated in appendix 5. Where existing systems vary from the configurations illustrated there and cannot be equated to a standard system, they shall be referred to the appropriate approving authority for special consideration.

345.-349. RESERVED.

SECTION 5. STANDARD MINIMUMS

350. STANDARD STRAIGHT-IN MINIMUMS. Tables 9 and 10 specify the lowest civil and military minimums which may be prescribed for various combinations of electronic and visual navigation aids. Lower minimums based on special equipment or air crew qualifications may be authorized only by approving authorities. Higher minimums shall be specified where required by application of criteria contained elsewhere in this handbook.

351. STANDARD CIRCLING MINIMUMS. Table 11 specifies the lowest civil and military minimums which may be prescribed for circling approaches. See also paragraph 330c. The MDA established by application of the minimums specified in this paragraph shall be rounded to the next higher 20 feet.

352.-359. RESERVED.

SECTION 6. ALTERNATE MINIMUMS

360. STANDARD ALTERNATE MINIMUMS. Minimums authorized when an airport is to be used as an alternate airport appear in table 12. The ceiling and visibility specified shall NOT be lower than the circling HAA and visibility, or as specified in military directives for military operations.

361.-369. RESERVED.

SECTION 7. DEPARTURES

370. STANDARD TAKEOFF MINIMUMS. Where applicable, civil standard takeoff minimums are specified by the number of engines on the aircraft. Takeoff minimums are stated as visibility only, except where the need to see and avoid an obstacle makes a ceiling value necessary. In this case the published procedure shall identify the location of the controlling obstacle. Takeoff minimums for military operations shall be as stated in the appropriate service directives.

Table 9. CIVIL STANDARD STRAIGHT-IN MINIMUMS

	NONPRECISION APPROACHES					
	NONPRECISION APPROACHES Procedures associated with 14 CFR Part 97.23, 25, 27, 31, 33, and 35					
	APPROACH LIGHT CONFIGURATION	CAT →	A – B – C		D	
		HAT[1]	Vis	RVR	Vis	RVR
1	NO LIGHTS	250	1	5000	1	5000
2	ODALS	250	3/4	4000	1	5000
3	MALS	250	3/4	4000	1	5000
4	SSALS/SALS	250	3/4	4000	1	5000
5	MALSR	250	1/2[2]	2400	1[3]	5000
6	SSALR	250	1/2[2]	2400	1[3]	5000
7	ALSF-1	250	1/2[2]	2400	1[3]	5000
8	DME Arc Any Light Configuration	500	1	5000	1	5000

[1] Add 50 ft to HAT for VOR without FAF or NDB with FAF.
Add 100 ft to HAT for NDB without FAF.
[2] For NDB approaches, 3/4 mile or RVR 4000.
[3] For LOC, 3/4 miles or RVR 4000.

	PRECISION APPROACHES					
	14 CFR Part 97.29					
	APPROACH LIGHT CONFIGURATION	CAT →	A – B – C		D	
		HAT[4]	Vis	RVR	Vis	RVR
9	NO LIGHTS	200	3/4	4000	3/4	4000
10	MALSR	200	1/2	2400	1/2	2400
11	SSALR	200	1/2	2400	1/2	2400
12	ALSF-1	200	1/2	2400	1/2	2400
13	ALSF-1-TDZ/CL MALSR-TDZ/CL SSALR-TDZ/CL	200	-	1800	-	1800

[4] ILS includes LOC, GS, and OM (or FAF). With Offset LOC (max 3°). HAT is 250 and RVR below 2400 is not authorized.

NOTE: HIRL is required for RVR. Runway edge lights required for night.

CHAPTER 4. ON-AIRPORT VOR (NO FAF)

400 GENERAL. This chapter is divided into two sections; one for low altitude procedures and one for high altitude teardrop penetration procedures. These criteria apply to procedures based on a VOR facility located on an airport in which no final approach fix (FAF) is established. These procedures must incorporate a procedure or a penetration turn. An ON-AIRPORT facility is one which is located:

a. For Straight-In Approach. Within one mile of the nearest portion of the landing runway.

b. For Circling Approach. Within one mile of the nearest portion of the usable landing surface of the airport.

401.-409. RESERVED.

SECTION 1. LOW ALTITUDE PROCEDURES

410. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

411. INITIAL APPROACH SEGMENT. The initial approach fix is received by overheading the navigation facility. The initial approach is a procedure turn (PT). The criteria for the PT areas are contained in paragraph 234.

412. INTERMEDIATE SEGMENT. This type of procedure has no intermediate segment. Upon completion of the PT, the aircraft is on final approach.

413. FINAL APPROACH SEGMENT. The final approach begins where the PT intersects the FAC.

a. Alignment. The alignment of the FAC with the runway centerline determines whether a straight-in or circling-only approach may be established.

(1) Straight-In. The angle of convergence of the FAC and the extended runway centerline shall not exceed 30°. The FAC should be aligned to intersect the extended runway centerline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the runway threshold and a point 5,200 feet outward from the runway threshold. Also, where an operational advantage can be achieved, a FAC which does not intersect the runway centerline or intersects it at a distance greater than 5,200 feet from the threshold may be established, provided that such course lies within 500 feet, laterally, of the extended runway centerline at a point 3,000 feet outward from the runway threshold. Straight-in category C, D, and E minimums are not authorized when the final approach course intersects the extended runway centerline at a an angle greater than 15° and a distance less than 3,000 feet (see figure 38).

(2) Circling Approach. When the final approach course alignment does not meet the criteria for straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the center of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to pass through any portion of the usable landing surface (see figure 39).

b. Area. Figure 40 illustrates the final approach primary and secondary areas. The primary area is longitudinally centered on the final approach course, and is 10 miles long. The primary area is 2 miles wide at the facility and expands uniformly to 6 miles at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 1.34 miles on each side of the primary area at 10 miles from the facility. When the 5-miles PT is used, only the inner 5 miles of the final approach area need be considered.

c. Obstacle Clearance.

(1) Straight-in. The minimum obstacle clearance in the primary area is 300 feet. In the secondary area, 300 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area is found in paragraph 523b(3).

(2) Circling Approach. In addition to the minimum requirements specified in paragraph 413c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

Figure 38. ALIGNMENT OPTIONS FOR FINAL APPROACH COURSE. On-Airport VOR, No FAF. Straight-in Approach Procedure. Par. 413a(1).

Figure 39. ALIGNMENT OPTIONS FOR FINAL APPROACH COURSE. On-Airport VOR. No FAF. Circling Approach Procedure. Par 413a(2).

Figure 40. FINAL APPROACH PRIMARY AND SECONDARY AREAS. On-Airport VOR. No FAF. Par 413b.

d. PT Altitude (Descent Gradient). The PT completion altitude shall be within 1,500 feet of the MDA (1000 feet with a 5-mile PT), provided the distance from the facility to the point where the final approach course intersects the runway centerline (or the first usable portion of the landing area for "circling only" procedures) does not exceed 2 miles. When this distance exceeds 2 miles, the maximum difference between the PT completion altitude and the MDA shall be reduced at the rate of 25 feet for each one-tenth of a mile in excess of 2 miles (see figure 41).

NOTE: For those procedures in which the final approach does NOT intersect the extended runway centerline within 5200 feet of the runway threshold (see paragraph 413a(1)) the assumed point of intersection for computing the distance from the facility shall be 3000 feet from the runway threshold. See figure 38.

**Figure 41. PT ALTITUDE.
On-Airport VOR, No FAF. Par 413d.**

Figure 42. USE OF STEPDOWN FIX. On-Airport VOR. No FAF. Par 413e.

e. Use of a Stepdown Fix. Use of a stepdown fix (paragraph 288c) is permitted provided the distance from the facility to the stepdown fix does not exceed 4 miles. The descent gradient between PT completion altitude and stepdown fix altitude shall not exceed 150 ft/NM. The descent gradient will be computed based upon the difference in PT completion altitude minus stepdown fix altitude, divided by the specified PT distance, minus the facility to stepdown fix distance. Obstacle clearance may be reduced to 250 feet from the stepdown fix to the MAP/FEP. See figure 42, paragraphs 251, 252, and 253.

f. MDA. Criteria for determining the MDA are contained in chapter 3.

414. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is the facility (see figure 42). The missed approach surface shall commence over the facility at the required height. (see paragraph 274).

415.-419. RESERVED.

SECTION 2. HIGH ALTITUDE TEARDROP PENETRATIONS

420. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

421. INITIAL APPROACH SEGMENT (IAF). The IAF is received by overheading the navigation facility. The initial approach is a teardrop penetration turn. The criteria for the penetration turn are contained in paragraph 235.

422. INTERMEDIATE SEGMENT. This procedure has no intermediate segment. Upon completion of the penetration turn, the aircraft is on final approach.

423. FINAL APPROACH SEGMENT. An aircraft is considered to be on final approach upon completion of the penetration turn. However, the final approach segment begins on the FAC 10 miles from the facility. That portion of the penetration procedure prior to the 10-mile point is treated as the initial approach segment. See figure 43.

a. Alignment. Same as low altitude (paragraph 413a).

b. Area. Figure 43 illustrates the final approach primary and secondary areas. The primary area is longitudinally centered on the FAC and is 10 miles long. The primary area is 2 miles wide at the facility and expands uniformly to 8 miles at a point 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, and expands uniformly to 2 miles each side of the primary area at a point 10 miles from the facility.

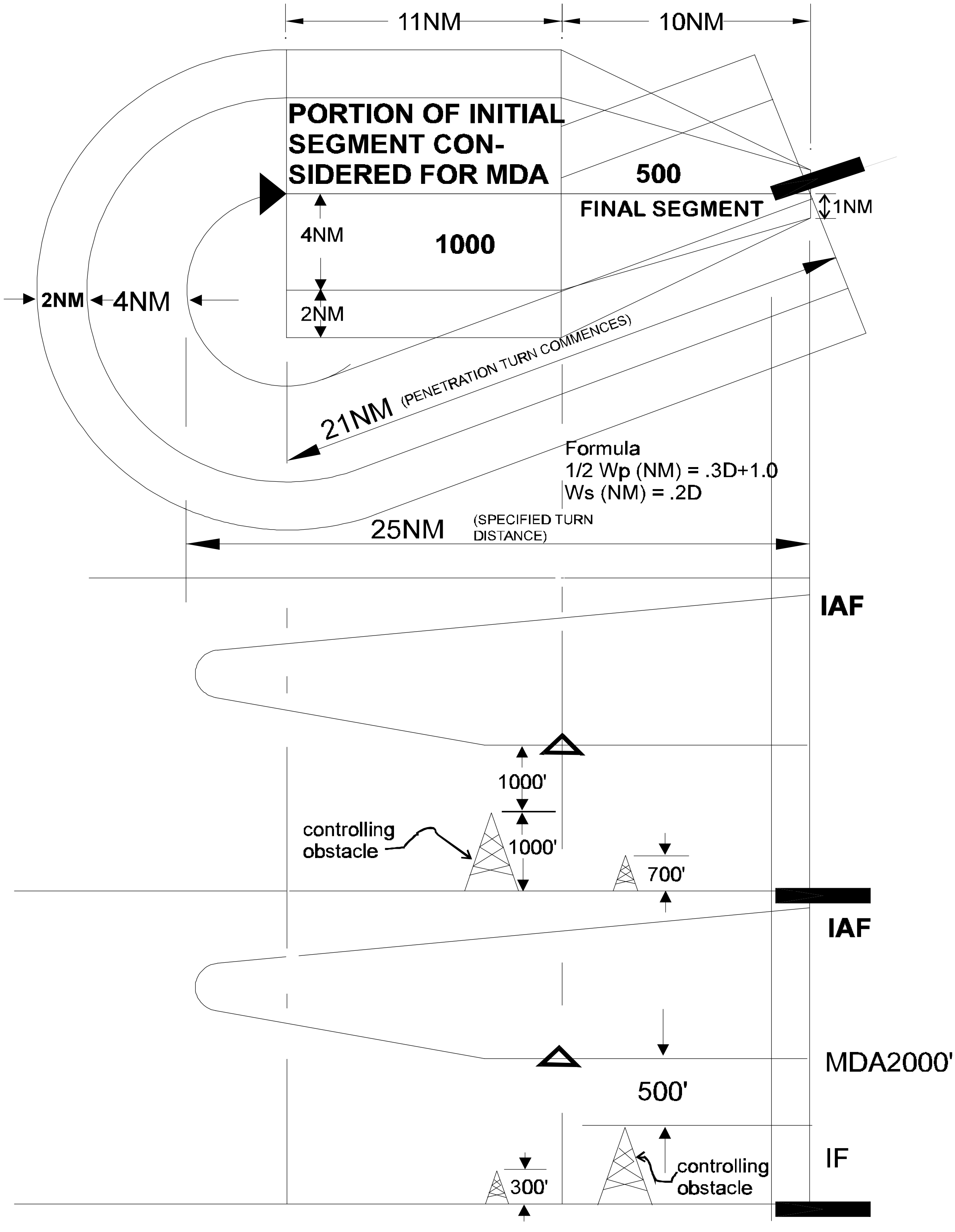


Figure 43. PENETRATION TURN. On-Airport VOR. No FAF. Par 423.

c. Obstacle Clearance.

(1) Straight-In. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum ROC at any given point in the secondary area is found in paragraph 232c.

(2) Circling Approach. In addition to the minimum requirements specified in paragraph 423c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. Penetration Turn Altitude *(Descent Gradient).* The penetration turn completion altitude shall be at least 1,000 feet, but not more than 4,000 feet above the MDA on final approach.

e. Use of Stepdown Fix. The use of the stepdown fix is permitted provided the distance from the facility to the stepdown fix does not exceed 10 miles (see paragraph 288c).

f. MDA. In addition to the normal obstacle clearance requirement of the final approach segment (see paragraph 423c), the MDA specified shall provide at least 1,000 feet of clearance over obstacles in the portion of the initial approach segment between the final approach segment and the point where the assumed penetration turn track intercepts the inbound course (see figure 43).

424. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is the facility (see figure 43). The missed approach surface shall commence over the facility at the required height (see paragraph 274).

425.-499. RESERVED.

Figure 51. TYPICAL STRAIGHT-IN FINAL APPROACHES. VOR WITH FAF. Par 513b.

segment shall provide adequate distance for an aircraft to make the required descent, and to regain course alignment when a turn is required over the facility. Table 14 shall be used to determine the minimum length needed to regain the course.

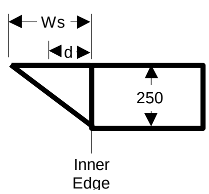
c. Obstacle Clearance.

(1) Straight-In Landing. The minimum obstacle clearance in the primary area is 250 feet. In the secondary area, 250 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum obstacle clearance at any given point in the secondary area is:

$$ROC = 250 \times \frac{Ws - d}{Ws}$$

Where Ws = Width of Secondary

d = distance from inner edge



(2) Circling Approach. In addition to the minimum requirements specified in paragraph 513c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. Descent Gradient. Paragraph 252 applies.

Table 14. MINIMUM LENGTH OF FINAL APPROACH SEGMENT-VOR (MILES).

Approach Category	Magnitude of Turn over Facility (Degrees)		
	10	20	30
A	1.0	1.5	2.0
B	1.5	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

NOTE: *This table may be interpolated. If the minimum lengths specified in the table are not available, straight-in minimums are not authorized. See figure 51 for typical final approach areas.*

e. Use of Fixes. Criteria for the use of radio fixes are contained in chapter 2, section 8. Where a procedure is based on a PT and an on-airport facility is the PT fix, the distance from the facility to the FAF shall not exceed 4 miles.

f. MDA. Criteria for determining the MDA are contained in chapter 3, section 2.

514. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. For VOR procedures, the MAP and surface shall be established as follows:

a. Off-Airport Facilities.

(1) Straight-In. The MAP is a point on the FAC which is **NOT** farther from the FAF than the runway threshold (see figure 52). The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

(2) Circling Approach. The MAP is a point on the FAC which is **NOT** farther from the FAF than the first usable portion of the landing area. The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

Figure 52. MAP.
Off-Airport VOR with FAF. Par 514a(1).

b. On-Airport Facilities. The MAP is a point on the FAC which is **NOT** farther from the FAF than the facility. The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

515.-519. RESERVED.

SECTION 2. TACAN AND VOR/DME

520. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

521. INITIAL SEGMENT. Due to the fixing capability of TACAN and VOR/DME a PT initial approach may not be required. Criteria for initial approach segments are contained in chapter 2, section 3.

522. INTERMEDIATE SEGMENT. Criteria for the intermediate segment are contained in chapter 2, section 4.

523. FINAL APPROACH SEGMENT. TACAN and VOR/DME final approaches may be based either on arcs or radials. The final approach begins at a FAF and ends at the MAP. The MAP is always marked with a fix.

a. Radial Final Approach. Criteria for the radial final approach are specified in paragraph 513.

b. Arc Final Approach. The final approach arc shall be a continuation of the intermediate arc. It shall be specified in NM and tenths thereof. Arcs closer than 7 miles (15 miles for high altitude procedures) and farther than 30 miles from the facility shall **NOT** be used for final approach. No turns are permitted over the FAF.

(1) Alignment. For straight-in approaches, the final approach arc shall pass through the runway threshold when the angle of convergence of the runway centerline and the tangent of the arc does not exceed 15°. When the angle exceeds 15°, the final approach arc shall be aligned to pass through the center of the airport and only circling minimums shall be authorized. See figure 53.

Figure 53. ARC FINAL APPROACH ALIGNMENT. Arc Aligned to Threshold. TACAN or VOR/DME. Par 523b(1).

(2) Area. The area considered for obstacle clearance in the arc final approach segment starts at the FAF and ends at the runway or MAP, whichever is encountered last. It should **NOT** be more than 5 miles long. It shall be divided into primary and secondary areas. The primary area is 8 miles wide, and extends 4 miles on either side of the arc. A secondary area is on each side of the primary area. The secondary areas are 2 miles wide on each side of the primary area (see figure 54).

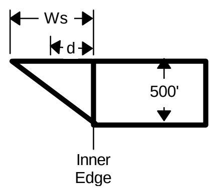
Figure 54. ARC FINAL APPROACH AREA. TACAN or VOR/DME. Par 523b(2)

(3) Obstacle Clearance. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge.

$$\text{Secondary } ROC = 500 \times \frac{W_S - d}{W_S}$$

Where d = distance from inner edge

W_S = Width of secondary area



(4) Descent Gradient. Criteria for descent gradients are specified in paragraph 252.

(5) Use of Fixes. Fixes along an arc are restricted to those formed by radials from the VORTAC facility which provides the DME signal. Criteria for such fixes are contained in chapter 2, section 8.

(6) MDA. Straight-in MDA's shall not be specified lower than circling for arc procedures. Criteria for determining the circling MDA are contained in chapter 3, section 2.

524. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP shall be a radial/DME fix. The missed approach surface shall commence over the fix and at the required height. Also see paragraph 514.

NOTE: The arc missed approach course may be a continuation of the final approach arc.

525.-599. RESERVED.

CHAPTER 6. NDB PROCEDURES ON-AIRPORT FACILITY, NO FAF

600. GENERAL. This chapter is divided into two sections: one for low altitude procedures and one for high altitude teardrop penetration procedures. These criteria apply to NDB procedures based on a facility located on the airport in which no FAF is established. These procedures must incorporate a PT or a penetration turn. An on-airport facility is one which is located:

a. For Straight-In Approach. Within 1 mile of any portion of the landing runway.

b. For Circling Approach. Within 1 mile of any portion of the usable landing surface on the airport.

601.-609. RESERVED.

SECTION 1. LOW ALTITUDE PROCEDURES

610. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

611. INITIAL APPROACH SEGMENT. The IAF is received by overheading the navigation facility. The initial approach is a PT. Criteria for the PT areas are contained in paragraph 234.

612. INTERMEDIATE SEGMENT. This type of procedure has no intermediate segment. Upon completion of the PT, the aircraft is on final approach.

613. FINAL APPROACH SEGMENT. The final approach begins where the PT intersects the FAC.

a. Alignment. The alignment of the FAC with the runway centerline determines whether a straight-in or circling-only approach may be established.

(1) Straight-In. The angle of convergence of the FAC and the extended runway centerline shall not exceed 30°. The FAC should be aligned to intersect the extended runway centerline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the runway threshold and a point 5,200 feet outward from the runway threshold. Also, where an operational advantage can be achieved, a FAC which does not intersect the runway centerline or intersects it at a distance greater than 5,200 feet from the threshold may be established, provided that such course lies within 500 feet, laterally, of the extended runway centerline at a point 3,000 feet outward from the runway threshold. Straight-in category C, D, and E minimums are not authorized when the final approach course intersects the extended runway centerline at a an angle greater than 15° and a distance less than 3,000 feet (see figure 55).

(2) Circling Approach. When the FAC alignment does not meet the criteria for straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the center of the landing area. When an operational advantage can be achieved, the FAC may be aligned to pass through any portion of the usable landing surface (see figure 56).

b. Area. Figure 57 illustrates the final approach primary and secondary areas. The primary area is longitudinally centered on the FAC and is 10 miles long. The primary area is 2.5 miles wide at the facility and expands uniformly to 6 miles wide at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, and expands uniformly to 1.34 miles on each side of the primary area at 10 miles from the facility. When the 5-mile PT is used, only the inner 5 miles of the final approach area need be considered.

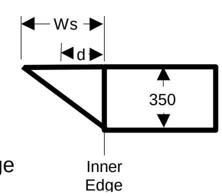
c. Obstacle Clearance.

(1) Straight-In. The minimum obstacle clearance in the primary area is 350 feet. **Exception:** Military users may apply a minimum obstacle clearance in the primary area of 300 feet. In the secondary area, 350 feet (or 300 feet, as applicable) of clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. To determine ROC in the secondary area, use the following formula:

$$ROC = 350 \times \frac{Ws - d}{Ws}$$

Where Ws = Width of Secondary

d = distance from inner edge

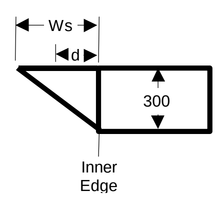


Exception: Military users utilize the following formula:

$$ROC = 300 \times \frac{Ws - d}{Ws}$$

Where Ws = Width of Secondary

d = distance from inner edge



(2) Circling Approach. In addition to the minimum requirements specified in paragraph 613c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. PT Altitude (Descent Gradient). The PT completion altitude shall be within 1,500 feet of the MDA (1,000 feet with 5 mile PT), provided the distance from the facility to the point where the FAC intersects the runway centerline (or the first usable portion of the landing area for "circling only" procedures) does not exceed 2 miles. When this distance exceeds 2 miles, the maximum difference between the PT completion altitude and the MDA shall be reduced at the rate of 25 feet for each one-tenth of a mile in excess of 2 miles (see figure 58).

NOTE: *For those procedures in which the FAC does not intersect the extended runway centerline within 5,200 feet of the runway threshold (paragraph 613a(1), the assumed point of intersection for computing distance from the facility shall be 3,000 feet from the runway* threshold (see *figure 55).*

Figure 55. ALIGNMENT OPTIONS FOR FAC. On-Airport NDB. No FAF. Straight-In Procedure. Par 613a(1).

Figure 56. ALIGNMENT OPTIONS FAC.
On-Airport NDB. No FAF.
Circling Approach. Par 613a(2).

Figure 57. FINAL APPROACH PRIMARY AND SECONDARY AREAS. On-Airport NDB. No FAF. Par 613b.

Figure 58. PT ALTITUDE.
On-Airport NDB. No FAF. Par 613d.

e. Use of a Stepdown Fix. Use of a stepdown fix (paragraph 288c) is permitted provided the distance from the facility to the stepdown fix does not exceed 4 miles. The descent gradient between PT completion altitude and stepdown fix altitude shall not exceed 150 ft/NM. The descent gradient will be computed based upon the difference in PT completion altitude minus stepdown fix altitude, divided by the specified PT distance, minus the facility to stepdown fix distance. Obstacle clearance may be reduced to 300 feet (**Exception:** Military 250 feet) from the stepdown fix to the MAP/FEP. See figure 59, paragraphs 251, 252, and 253.

f. MDA. Criteria for determining the MDA are contained in chapter 3, section 2.

614. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is the facility. See figure 59. The missed approach surface shall commence over the facility at the required height (see paragraph 274).

615.-619. RESERVED.

Figure 59. USE OF STEPDOWN FIX. On-Airport NDB. No FAF. Par 613e.

SECTION 2. HIGH ALTITUDE TEARDROP PENETRATIONS

620. FEEDER ROUTES. Criteria for feeder routes are contained in paragraph 220.

621. INITIAL APPROACH SEGMENT. The IAF is received by overheading the navigation facility. The initial approach is a teardrop penetration turn. The criteria for the penetration turn are contained in paragraph 235.

622. INTERMEDIATE SEGMENT. The procedure has no intermediate segment. Upon completion of the penetration turn, the aircraft is on final approach.

623. FINAL APPROACH SEGMENT. An aircraft is considered to be on final approach upon completion of the penetration turn. However, the final approach segment begins on the FAC 10 miles from the facility. That portion of the penetration procedure prior to the 10-mile point is treated as the initial approach segment (see figure 60).

a. Alignment. Same as low altitude criteria (see paragraph 613a).

b. Area. Figure 60 illustrates the final approach primary and secondary areas. The primary area is longitudinally centered on the FAC, and is 10 miles long. The primary area is 2.5 miles wide at the facility, and expands uniformly to 8 miles at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 2 miles each side of the primary area at 10 miles from the facility.

c. Obstacle Clearance.

(1) Straight-In. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. The minimum ROC at any given point in the secondary area is found in paragraph 232c.

(2) Circling Approach. In addition to the minimum requirements specified in paragraph 623c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. Penetration Turn Altitude (Descent Gradient*).* The penetration turn completion altitude shall be at least 1,000 feet, but not more than 4,000 feet above the MDA on final approach.

e. Use of a Stepdown Fix. Use of a stepdown fix (paragraph 288c) is permitted, provided the distance from the facility to the stepdown fix does not exceed 10 miles (see paragraph 251).

f. MDA. In addition to the normal obstacle clearance requirements of the final approach segment (see paragraph 623c), the MDA specified shall provide at least 1,000 feet of clearance over obstacles in that portion of the initial approach segment between the final approach segment and the point where the assumed penetration turn track intercepts the inbound course (see figure 60).

624. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is the facility (see figure 60). The missed approach surface shall commence over the facility at the required height (see paragraph 274).

625.-699. RESERVED.

Figure 60. PENETRATION TURN. On-Airport NDB. No FAF. Par 623.

expands uniformly to 1 mile each side of the primary area at 15 miles from the facility. Final approaches may be made to airports which are a maximum of 15 miles from the facility. The OPTIMUM length of the final approach segment is 5 miles. The MAXIMUM length is 10 miles. The MINIMUM length of the final approach segment shall provide adequate distance for an aircraft to make the required descent, and to regain course alignment when a turn is required over the facility. The following table shall be used to determine the minimum length needed to regain the course.

Table 15. MINIMUM LENGTH OF FINAL APPROACH SEGMENT - NDB (Miles)

Approach Category	**Magnitude of Turn over Facility (Degrees)**		
	10	20	30
A	1.0	1.5	2.0
B	1.5	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

NOTE: *This table may be interpolated. If turns of more than 30° are required, or if the minimum lengths specified in the table are not available for the procedure, straight-in minimums are* ***NOT*** *authorized. See figure 66 for typical final approach areas.*

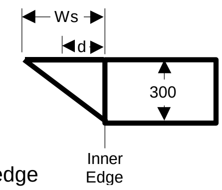
Figure 66. TYPICAL FINAL APPROACH AREAS. NDB with FAF. Par 713b.

c. Obstacle Clearance.

(1) Straight-In. The minimum obstacle clearance in the primary area is 300 feet. **Exception**: Military users may apply a minimum obstacle clearance in the primary area of 250 feet. In the secondary area, 300 feet (or 250 feet, as applicable) of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum ROC at any given point in the secondary area is:

$$ROC = 300 \times \frac{Ws - d}{Ws}$$

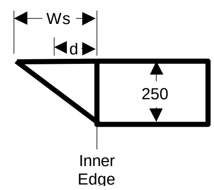
Where Ws = Width of Secondary
d = distance from inner edge



Exception: Military users utilize the formula to determine ROC in the secondary area. Annotate joint civilian/military SIAP's that civilian users add 50 feet to all minimums if 250 ROC is used.

$$ROC = 250 \times \frac{Ws - d}{Ws}$$

Where Ws = Width of Secondary
d = distance from inner edge



(2) Circling Approach. In addition to the minimum requirements specified in paragraph 713c(1), obstacle clearance in the circling area shall be as prescribed in chapter 2, section 6.

d. Descent Gradient. Paragraph 252 applies.

e. Use of Fixes. Criteria for the use of radio fixes are contained in chapter 2, section 8. Where a procedure is based on a PT and an on-airport facility is the PT fix, the distance from the facility to the FAF shall not exceed 4 miles.

f. MDA. Criteria for determining the MDA are contained in chapter 3, section 2.

714. MISSED APPROACH SEGMENT. Criteria for the missed approach segment are contained in chapter 2, section 7. The MAP and surface shall be established as follows:

a. Off-Airport Facilities.

(1) Straight-In. The MAP is a point on the FAC which is **NOT FARTHER** from the FAF than the runway threshold. The missed approach surface shall commence over the MAP at the required height (see paragraph 274 and figure 67).

Figure 67. MAP.
Off-Airport NDB with FAF. Par 714a(1).

(2) Circling Approach. The MAP is a point on the FAC which is NOT FARTHER from the FAF than the first usable portion of the landing area. The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

b. On-Airport Facilities. The MAP is a point on the FAC which is **NOT FARTHER** from the FAF than the facility. The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

715.-799. RESERVED.

SECTION 3. ILS CAT I FINAL APPROACH

930. FINAL APPROACH SEGMENT. The final approach segment shall begin at the point where the glide slope is intercepted, and descend to the authorized decision height (DH**)**. Where possible, this point shall be coincidental with a designated FAF. At locations where it is not possible for the point of glide slope intercept to coincide with a designated FAF, the point of glide slope interception shall be located PRIOR to the FAF. Where a designated FAF cannot be provided, specific authorization by the approving authority is required.

a. Alignment. The final approach course is normally aligned with the runway centerline. Where a unique operational requirement indicates a need for an offset course, it may be approved, provided the course intersects the runway centerline at a point 1,100 to 1,200 feet toward the runway threshold from the DH point on the glide slope and the angular divergence of the course does **NOT** exceed 3°.

b. Area. The area considered for obstacle clearance in the final approach segment consists of a final approach area and transitional surfaces.

(1) Final Approach Area. The final approach area has the following dimensions:

(a) Length. The final approach area is 50,000 feet long measured outward along the final approach course from a point beginning 200 feet outward from the runway threshold. Where operationally required by other procedural considerations due to existing obstacles, the length may be increased as shown in figure 76. The final approach area used shall only be that portion of the area which is between the glide slope interception point and the point 200 feet from the threshold.

(b) Width. The final approach area is centered on the extended runway centerline except in those cases where an offset localizer is required, as provided in paragraph 930a, in which case the area is centered on the final approach course. The area has a width of 1,000 feet at the point 200 feet from the threshold and expands uniformly to a width of 16,000 feet at a point 50,000 feet from the point of beginning. This width further expands uniformly where greater length is required as in paragraph 930b(1)(a). See figure 76.

.

Figure 76. ILS CATEGORY I FINAL APPROACH AREA. Par 930.

The width either side of the centerline at a given distance "d" from the point of beginning can be found by using the formula "500+.15D=1/2W"; e.g.; 500+.15 X 50,000= 8,000, which is ½ width; therefore, the total width is 16,000 feet at the 50,000 foot point.

NOTE: Where glide slope interception occurs at a distance greater than 50,200 feet from the threshold, the final approach area and the final approach surface may be extended symmetrically to a maximum distance dictated by the usability of the glide slope.

931. FINAL APPROACH OBSTACLE CLEARANCE SURFACE (OCS). The final approach OCS is an inclined plane which originates at the runway THR elevation, 975 feet before ground point of intercept (GPI), and overlies the final approach area. The surface is divided into two sections: an inner 10,000 foot section and an outer 40,000 foot section. The slope of the surface changes at the 10,000 foot point. The exact gradient differs according to the angle at which the glide slope is established (see figure 77). Paragraphs 934 and 935 address application of the OCS.

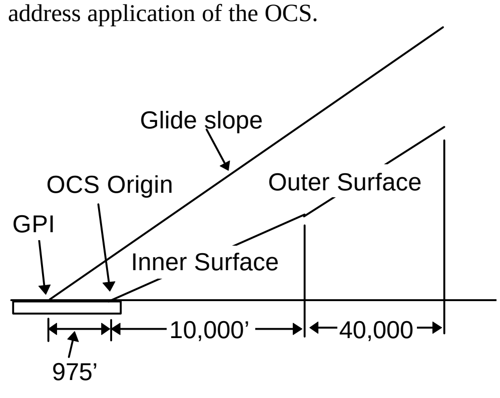


Figure 77. OBSTACLE CLEARANCE SURFACES. Par 931.

932. TRANSITIONAL SURFACES. Transitional surfaces for ILS Category I are inclined planes with a slope of 7:1 which extend outward and upward from the edge of the final approach area, starting at the height of the applicable final approach surface and extending for a lateral distance of 5,000 feet at the right angles to the final approach course (see figure 76).

933. DELETED

934. OBSTACLE CLEARANCE. No obstacle shall penetrate the applicable final approach OCS specified in paragraph 931 or the transitional surfaces specified in paragraph 932. Compare obstacle height to the appropriate OCS/transitional surface using the formulae below.

a. Inner OCS (OCS_I). Calculate the height of the OCS_I at any distance D less than 10,975 feet from GPI using the following formula:

$$OCS_I \text{ Height Above THR } = \left[\left(\tan(gs) - 0.02366\right) \times D\right] - 20$$

where: gs = glide slope angle
D = distance from GPI in feet

b. Outer OCS (OCS_O). Calculate the height of the OCS_O at any distance D equal to or greater than 10,975 feet from GPI using the following formula:

$$OCS_O \text{ Height Above THR } = \left[\left(\tan(gs) - 0.01866\right) \times D\right] - 75$$

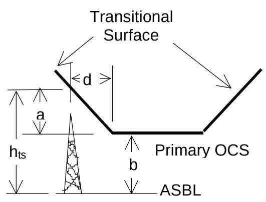
where: gs = glide slope angle
D = distance from GPI in feet

c. Transitional Surface. Calculate the height of the transitional surface (h_{ts}) at any distance (d) from the edge of the primary area measured perpendicular to the final approach course using the following formulae.

(1) $a = \frac{d}{7}$

(2) $h_{ts} = a + b$

Where a = amount of surface adjustment
b = OCS_I or OCS_O as appropriate



935. EFFECT OF OBSTACLES INSIDE THE DH. See paragraph 251 for the assessment of the visual portion of an ILS approach.

936. GLIDE SLOPE. In addition to the required obstacle clearance, the following shall apply to the selection of glide slope angle and antenna location:

a. Glide slope Angle. All new and relocated ILS facilities will be commissioned with a 3° glide slope angle. Existing facilities may continue in operation without change in the established glide slope angle. Angles greater than 3° or less than 2° shall not be established without approval of the Flight Standards Service, FAA, Washington, D.C., or appropriate military authority as necessary.

NOTE. Where PAR serves a runway that is also served by a non-radar precision instrument approach and/or a VGSI, the PAR, the non-radar precision instrument approach, and the VGSI glide slope angles and runway point of intercept (RPI) shall coincide. The PAR glide slope angle shall be within 0.20 of the non-radar precision instrument approach/VGSI glide slope angle and the RPI shall be within plus or minus 50 feet (30 feet for PAPI and PVGSI) of the non-radar precision approach RPI and/or VGSI runway reference point (RRP).

b. Glide slope Threshold Crossing Height (TCH). See paragraph 980 for TCH requirements. A height as low as 32 feet for military airports may be used at locations where special consideration of the glidepath angle and antenna location are required. Where the glide slope TCH exceeds 60 feet, consider relocating the landing threshold to ensure effective placement of the approach light system. See appendix 2 for a method of computing TCH.

937. RELOCATION OF GLIDE SLOPE. Where the OCS associated with a 3° glide slope is penetrated, and sufficient length of runway is available, the glide slope may be moved the required distance down the runway to ensure the OCS is clear. Where the glide slope threshold crossing height exceeds 60 feet, consider relocating the landing threshold to ensure effective placement of the approach light system. The minimum distance between the GPI and the runway threshold is 775 feet. (No minimum GPI distance need be applied to military locations provided the OCS is clear and TCH standards are met.)

938. DECISION HEIGHT (DH).

a. Minimum DH. For category I systems, the DH shall not be less than 200 feet above touchdown zone elevation (TDZE).

b. Adjustment of DH.

(1) Primary Surface Penetrations. When the OCS associated with a 3° glide slope is penetrated, and the approving authority will not approve an angle in excess of 3°, and the runway length does not permit a compensating adjustment, the DH shall be increased accordingly. See figure 78. Use the formulae below to determine the new DH.

$$(1) \quad d = \frac{(OH\ -\ THRe) + 20}{tan(gs)\ -\ 0.02366}$$

$$(2) \quad HAT = (tan(gs) * d) + (THRe - TDZE)$$

$$(3) \quad DH = TDZE + HAT$$

where d = DH distance from GPI
OH = height of obstacle (MSL)
THRe = THR elevation
TDZE = Touchdown zone elevation
gs = glide slope angle

Application of this method need not require a DH that is more than 250 feet above the obstacle; however, the minimum HAT is 250 feet.

(2) Transitional Surface Penetrations. Where obstacles penetrate the transitional surface, and when deemed necessary, consider an adjustment in DH equal to the amount of penetration (see figure 79).

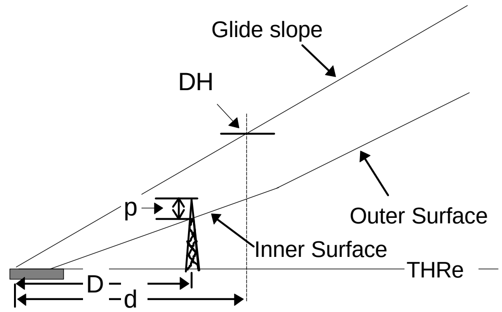


Figure 78. OCS PENETRATION. Par 938b(1).

939. RESERVED.

Figure 79. ADJUSTMENT OF DECISION HEIGHT. Par 938(b(2).

SECTION 4. ILS CAT I MISSED APPROACH

940. MISSED APPROACH SEGMENT. The missed approach segment begins at the MAP and ends at an appropriate point or fix where initial approach or en route obstacle clearance is provided. Missed approach procedures shall be based on PCG where possible.

941. MISSED APPROACH POINT (MAP). The MAP is a point on the FAC where the height of the glide slope equals the authorized DH.

942. STRAIGHT MISSED APPROACH. The straight missed approach area (maximum of 15° turn from FAC) starts at the MAP. The length of the area is 15 miles, measured along the missed approach course. The area has a width equal to that of the final approach area at the MAP and a width equal to that of the initial approach area at a point 15 miles from the MAP. The missed approach area is divided into 2 sections.

a. Section 1 starts at the MAP and is longitudinally centered on the missed approach course. It has the same width at the MAP as the final approach area. The total width increases to 1 mile at a point 1.5 miles from the MAP.

b. Section 2 starts at the end of section 1 and is centered on a continuation of the section 1 course. The width increases uniformly from 1 mile at the beginning to 12 miles at a point 13.5 miles from the beginning. A secondary area for reduction of obstacle clearance is identified within section 2. The secondary area is zero miles wide at the beginning and increases uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary areas (see figure 80).

Figure 80. ILS STRAIGHT MISSED APPROACH AREA. Par 942.

943. TURNING MISSED APPROACH. Where turns of less than 15° are required in a missed approach procedure, the provisions of paragraphs 942a and b apply. Where turns of MORE than 15° are required, they shall be specified to commence at an altitude which is at least 400 feet above the elevation of the TDZ. Altitudes required prior to commencing a turn shall be specified in the published procedure. Such turns are assumed to commence at the point where section 2 begins. The flight track and obstacle clearance radii used shall be as specified in table 5, paragraph 275. The inner boundary line shall commence at the edge of section 1 opposite the MAP. The outer and inner boundary lines shall flare to the width of the initial approach area 13.5 miles from the beginning of section 2. Secondary areas for reduction of obstacle clearance are identified within section 2. The secondary areas begin after completion of the turn. They are zero miles wide at the beginning and increase uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary area. See figure 81

Figure 81. ILS TURNING MISSED APPROACH AREA. Par 943.

944. MISSED APPROACH OBSTACLE CLEARANCE.

a. Straight Missed Approach Area. No obstacle in section 1 or section 2 may penetrate a 40:1 surface which originates at the MAP at the height of the final approach obstacle clearance surface, but not more than 250 feet below the DH, and which overlies the entire missed approach area.

b. Turning Missed Approach Area. Section 1 obstacle clearance is the same as that for straight missed approaches. To determine the obstacle clearance requirements in section 2, the dividing line between sections 1 and 2 is identified as "A-B-C". The height of the missed approach surface over any obstacle in section 2 is determined by measuring the distance from the obstacle to the nearest point on line A-B-C and computing the height according to the 40:1 ratio, starting at the height of the missed approach surface at the end of section 1.

c. Secondary Areas. Where secondary areas are considered, no obstacle may penetrate a 12:1 surface which slopes outward and upward from the missed approach surface.

d. Discontinuance. Where the 40:1 surface reaches a height of 1,000 feet below the missed approach altitude (paragraph 270) further application of the surface is not required.

945. COMBINATION STRAIGHT AND TURNING MISSED APPROACH AREA. If a straight climb to an altitude greater than 400 feet is necessary prior to commencing a missed approach turn, a combination straight and turning missed approach area must be constructed. The straight portion of this missed approach area is divided into sections 1 and 1A. The portion in which the turn is made is section 2.

b. **a. Straight Portion.** Sections 1 and 1A correspond respectively to sections 1 and 2 of the normal straight missed approach area and are constructed as specified in paragraph 942 except that section 1A has no secondary areas. Obstacle clearance is provided as specified in paragraph 944b. The length of section 1A is determined as shown in figure 82 and relates to the need to climb to a specified altitude prior to commencing the turn. The line A' -B' marks the end of section 1A. Point C' is 9,000 feet from the end of section 1A.

b. Turning Portion. Section 2 is constructed as specified in paragraph 943 except that it begins at the end of section 1A instead of the end of section 1. To determine the height which must be attained before commencing the missed approach turn, first identify the controlling obstacle on the side of section 1A to which the turn is to be made. Then measure the distance from this obstacle to the nearest edge of the section 1A area. Using this distance as illustrated in figure 82, determine the height of the 40:1 slope at the edge of section 1A. This height plus 250 feet (rounded off to the next higher 20-foot increment) is the height at which the turn should be started. Obstacle clearance requirements in section 2 are the same as those specified in paragraph 944b except that section 2 is expanded to start at Point C if no fix exists at the end of section 1A or if no course guidance is provided in section 2.

Figure 82. COMBINATION STRAIGHT AND TURNING MISSED APPROACH AREA. Par 945.

946. - 949. RESERVED.

SECTION 5. LOCALIZER AND LDA

950. FEEDER ROUTES, INTIAL APPROACH, AND INTERMEDIATE SEGMENTS. These criteria are contained in paragraphs 920, 921, 922, and 923.

951. USE OF LOCALIZER ONLY. Where no usable glide slope is available, a localizer-only (front or back course) approach may be approved, provided the approach is made on a LOC from a FAF located within 10 miles of the runway threshold. Criteria in this section are also applicable to procedures based on localizer type directional aids (LDA). Back course procedures shall not be based on courses which exceed 6° in width and shall not be approved for offset LOC.

952. ALIGNMENT. Localizers which are aligned within 3° of the runway alignment shall be identified as localizers. If the alignment exceeds 3°, they will be identified as LDA facilities. The alignment of the course for LDA facilities shall meet the final approach alignment criteria for VOR on-airport facilities. See chapter 5, paragraph 513, and figure 48.

953. AREA. The final approach area and transitional surface dimensions are as specified in paragraph 930. However, only that portion of the final approach area which is between the FAF and the runway need be considered as the final approach segment for obstacle clearance purposes. The optimum length of the final approach segment is 5 miles. The MINIMUM length of the final approach segment shall be sufficient to provide adequate distance for an aircraft to make the required descent. The area shall be centered on the FAC and shall commence at the runway threshold. For LDA procedures the final approach area shall commence at the facility and extend to the FAF. The MAP for LDA procedures shall not be farther from the FAF than a point adjacent to the landing threshold perpendicular to the FAC.

954. OBSTACLE CLEARANCE. The MOC in the final approach area shall be 250 feet. In addition, the MDA established for the final approach area shall assure that no obstacles penetrate the transitional surfaces. The transitional surfaces in localizer-only type approaches begin at a height not less than 250 feet below the MDA.

955. DESCENT GRADIENT. The OPTIMUM gradient in the final approach segment is 318 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 400 feet per mile. When maximum straight-in descent gradient is exceeded, then a "circling only" procedure is authorized. When a stepdown fix is incorporated, descent gradient criteria must be met from FAF to SDF and SDF to FEP. See paragraphs 251, 252, and 288a.

956. MDA. Because no glide slope is associated with a localizer-only approach, the lowest altitude on final approach is specified as an MDA, not a DH. The MDA adjustments specified in paragraph 232 shall be considered.

957. MISSED APPROACH SEGMENT. The criteria for the missed approach segment are contained in paragraphs 942, 943, and 945. The MAP is on the FAC not farther from the FAF than the runway threshold (first usable portion of the landing area for circling approach). The missed approach surface shall commence over the MAP at the required height (see paragraph 274).

958.-959. RESERVED.

SECTION 6. ILS CATEGORY (CAT) II

960.-969. RESERVED.

SECTION 7. ILS CAT III

970.-979. RESERVED.

SECTION 8. GLIDE SLOPE THRESHOLD CROSSING HEIGHT REQUIREMENTS

980. CAT I THRESHOLD CROSSING HEIGHT (TCH) REQUIREMENTS.

a. Standard. Provided there is not a problem with obstacles penetrating the final approach obstacle clearance surfaces, the ILS glide slope should be located to provide a commissioned TCH which will result in a wheel crossing height (WCH) of 30 feet for the types of aircraft with the greatest glidepath-to-wheel height normally expected to use the runway (see table 18A).

b. Deviations From Standard. The TCH shall not be commissioned at a height which would result in a WCH of less than 20 feet or greater than 50 feet for the types of aircraft with the greatest glidepath-to-wheel height normally expected to use the runway. These limits shall not be exceeded unless formally approved by a flight procedures standards waiver as outlined in Order 8260.19C or by the appropriate military authority as necessary.

NOTE: 60 feet is the maximum TCH.

c. Displaced Threshold Considerations. The TCH over a displaced threshold can be as low as that which will result in a WCH of not less than 10 feet for the largest aircraft normally expected to use the runway provided the TCH over the beginning of the full strength runway pavement suitable for landing meets TCH requirements.

981. CAT II AND III TCH REQUIREMENTS.

a. Standard. The commissioned TCH shall be between 50 and 60 feet with the optimum being 55 feet.

b. Deviations from the Standard. Any deviation must be formally approved by a flight procedures standards waiver as outlined in Order 8260.19 or by the appropriate military authority as necessary.

c. Temporary Exemption Clause. Order 8240.47 may be applied to a published precision system where the TCH is within the allowable limits in table 18A. If the new flight inspection derived TCH is within 3 feet of the published TCH but not within the limits of table 18A, operations may continue without waiver action for up to 365 days from the date the order is applied.

(1) If aircraft in height group 4 (see table 18A) have not been excluded from conducting CAT II or III operations on that runway, a TCH lower than 50 feet is not permitted unless the achieved ILS reference datum height (ARDH) has averaged 50 feet or higher.

(2) After 365 days, a flight procedures waiver must have been approved, the situation corrected, or CAT II and III operations canceled.

(3) Flight Standards Service or the appropriate military authority can authorize further deviation or immediately rescind this temporary exemption.

TABLE 18A

Representative Aircraft Type	Approximate Cockpit or Glidepath to Wheel Height	Recommended TCH ± 5 Feet	Remarks
HEIGHT GROUP 1 General aviation, Small commuters, Corporate turbojets, T-37, T-38, C-12, C-20, C-21, T-1, Fighter Jets	10 Feet or less	40 Feet	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
HEIGHT GROUP 2 F-28, CV-340/440/580, B-737, C-9, DC-9, DC-8, C-130, T-43, B-2, S-3	15 Feet	45 Feet	Regional airport with limited air carrier service.
HEIGHT GROUP 3 B-727/707/720/757, B-52, C-135, C-141, C-17, E-3, P-3, E-8	20 Feet	50 Feet	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 feet.
HEIGHT GROUP 4 B-747/767, L-1011, DC-10, A-300, B-1, KC-10, E-4, C-5, VC-25	25 Feet	55 Feet	Most primary runways at major airports

Note 1: To determine the minimum allowable TCH, add 20 feet to the glidepath-to-wheel height.
Note 2: To determine the maximum allowable TCH, add 50 feet to the glidepath-to-wheel height (precision approaches not to exceed 60 ft.).

982.-989. RESERVED.

SECTION 9. SIMULTANEOUS ILS PROCEDURES

990. GENERAL. Simultaneous dual and triple ILS approach procedures using ILS installations with parallel courses may be authorized when the minimum standards in this section and section 1 are met.

991. SYSTEM COMPONENTS. Simultaneous ILS approach procedures require the following basic compo-nents.

a. **An ILS specified in section 1** of this chapter for each runway. Adjacent markers of the separate systems shall be separated sufficiently to preclude interference at altitudes intended for use.

b. **ATC approved radar** for monitoring simulta-neous operations.

992. INOPERATIVE COMPONENTS. When any component specified in paragraph 991 becomes inoperative, simultaneous ILS approaches are not authorized on that runway.

993. FEEDER ROUTES. The criteria for feeder routes are contained in chapter 2, section 2.

994. INITIAL APPROACH SEGMENT. The criteria for the initial approach segment are contained in chapter 2, section 3. The initial approach shall be made from a facility or satisfactory radio fix by radar vector. Procedure and penetration turns shall not be authorized.

a. Altitude Selection. In addition to obstacle clearance requirements, the altitudes established for initial approach shall provide the following vertical separation between glide slope intercept altitudes.

(1) Dual. Simultaneous dual ILS approaches shall require at least 1,000 feet vertical separation between glide slope intercept altitudes for the two systems (see figure 96A).

(2) Triple. Simultaneous triple ILS approaches shall require at least 1,000 feet vertical separation between glide slope intercept altitudes for any combination of runways. No two runways share the same glide slope intercept altitude (see figure 96B).

b. Localizer Intercept Point. The localizer intercept point shall be established in accordance with paragraph 922. Intercept angles may not exceed 30°; 20° is optimum.

995. INTERMEDIATE APPROACH SEGMENT. Criteria for the intermediate segment are contained in paragraphs 241 and 242, except that simultaneous ILS procedures shall be constructed with a straight intermediate segment aligned with the FAC, and the minimum length shall be established in accordance with paragraph 922. The intermediate segment begins at the point where the initial approach intercepts the FAC. It extends along the inbound course to the GLIDE SLOPE intercept point.

996. FINAL APPROACH SEGMENT. Criteria for the final approach segment are contained in section 3 of this chapter.

997. FAC STANDARDS. The FAC's for simultaneous ILS approaches require the following:

a. Dual approaches shall have a minimum of 4,300 feet separation between parallel FAC's.

b. Triple approaches shall have a minimum of 5,000 feet separation between parallel FAC's. For triple parallel approach operations at airport elevations above 1,000 feet MSL, ASR with high resolution final monitor aids or high update radar with associated final monitor aids shall be required.

c. No Transgression Zone (NTZ). The NTZ shall be 2,000 feet wide equidistant between FAC's.

d. Normal Operating Zone (NOZ). The area between the FAC and the NTZ is half of the NOZ.

(1) The NOZ for dual simultaneous ILS approaches shall not be less than 1,150 feet in width each side of the FAC (see figure 97A).

(2) The NOZ for triple simultaneous ILS approaches shall not be less than 1,500 feet in width each side of the FAC (see figure 97B).

998. MISSED APPROACH SEGMENT. Except as stated in this paragraph, the criteria for missed approach are contained in section 4 of this chapter. A missed approach shall be established for each of the simultaneous systems. The minimum altitude specified for commencing a turn on a climb straight ahead for a missed approach shall not be less than 400 feet above the TDZE.

a. Dual. Missed approach courses shall diverge a minimum of 45°.

b. Triple. The missed approach for the center runway should continue straight ahead. A minimum of 45° divergence shall be provided between adjacent missed approach headings. At least one outside parallel shall have a turn height specified that is not greater than 500 feet above the TDZE for that runway.

999. RESERVED.

Figure 96B. INITIAL APPROACH SEGMENT FOR TRIPLE SUMULTANEOUS ILS. Par 994.

CHAPTER 10. RADAR PROCEDURES

1000. GENERAL. This chapter applies to approach procedures based on the use of ground and airborne radar. Four types of radar procedures are covered:

a. Precision Approach Radar (PAR). A radar display of azimuth, range, and glide slope information, which provides for precision approaches to a runway.

b. Airport Surveillance Radar. A radar installation with a display of azimuth and range, which provides a radar vectoring capability for final approach to an airport.

c. Simultaneous Radar Procedures. A radar or radars which serve parallel runways and provide for simultaneous approaches to authorized minimums.

d. Airborne Radar. A radar installation in an aircraft with a display of azimuth and range which provides a capability for an instrument approach when used with appropriate terrain, reflector, or transponder return.

1001. - 1009. RESERVED.

SECTION 1. PRECISION APPROACH RADAR (PAR)

1010. SYSTEM COMPONENTS. A PAR system consists of a PAR facility which meets the requirements for the operating agency.

1011. INOPERATIVE COMPONENTS. Failure of azimuth and range information renders the entire PAR inoperative. When the glide slope feature becomes inoperative, the PAR reverts to a non-precision approach system and non-precision minimums (paragraph 350) apply. In this case, obstacle clearance shall be as specified in paragraph 953 for localizer and LDA approaches.

1012. LOST COMMUNICATION PROCEDURES. The PAR procedure shall include instructions for the pilot to follow in the event of a loss of communications with the radar controller. Alternate lost communications procedures shall be established for use where multiple approaches are authorized.

1013. FEEDER ROUTES AND INITIAL APPROACH SEGMENTS. Navigational guidance for feeder routes and initial segments may be provided by surveillance radar, other navigation facilities, or a combination thereof. When radar is used as the primary means of navigation guidance, the criteria specified in section 4 of this chapter shall apply. When other navigational facilities are used as the primary means of navigational guidance, the criteria specified in chapter 2, sections 2 and 3, shall apply, as appropriate.

1014. INTERMEDIATE APPROACH SEGMENT. Navigational guidance in the intermediate segment may be provided by ASR, PAR, other navigation facilities, or combination thereof. Except as stated in this paragraph, the criteria for the intermediate segment are contained in chapter 2, section 4. The intermediate segment begins at the point where the initial approach course intercepts an extension of the FAC. This extension is the intermediate course. It extends along the inbound FAC to the point of interception of the GP. The minimum length of the intermediate segment depends on the angle at which the initial approach course intercepts the intermediate, and is specified in table 20. The MAXIMUM angle of interception shall be 90§.

Table 20. INTERMEDIATE SEGMENT ANGLE OF INTERCEPT VS. SEGMENT LENGTH.

Maximum Angle (Degrees)	Minimum Length (Miles)
15	1
30	2
45	3
60	4
75	5
90	6

NOTE: This table may be interpolated.

1015. DESCENT GRADIENT. Even though the minimum length of the intermediate segment may be less than that specified in chapter 2, section 4, intermediate descent criteria specified in paragraphs 242d and 243d shall be applied to at least 5 miles of flight track immediately prior to the glide slope intercept point.

1016. ALTITUDE SELECTION. Altitudes selected for the initial approach and intermediate approach segments provide required obstacle clearance as specified in chapter 2. In addition, the selected altitudes shall NOT be less than the glide slope interception altitude. Where PAR and ILS serve the same runway, the glide slope interception altitude should be the same for both, and the point of interception should be the OM wherever possible.

1017. - 1019. RESERVED.

SECTION 2. PAR FINAL APPROACH

1020. FINAL APPROACH SEGMENT. The final approach segment begins at the FAF. The FAF in PAR procedures is the point where interception of the glide slope occurs. The point of glide slope interception shall NOT be less than 3 miles from the landing threshold. When the glide slope is inoperative, the FAF is a point on the FAC within 5 miles of the landing threshold, but not less than the distance required by descent gradient criteria. The FAF for procedures without a glide slope should coincide with the FAF for PAR.

a. Alignment. The FAC shall be aligned with the runway centerline.

b. Area. The area considered for obstacle clearance in the final approach segment consists of a final approach area and transitional surfaces (see paragraph 1022). The final approach area has the following dimensions:

(1) Length. The final approach area is 50,000 feet long, measured outward along the FAC from a point beginning 200 feet outward from the runway threshold. Where operationally required by other procedural considerations due to existing obstacles, the length may be increased as shown in figure 98. The final approach area used shall only be that portion of the area which is between the glide slope interception point and the point 200 feet from the runway threshold.

Figure 98. PAR FINAL APPROACH AREA. Par 1020b.

(2) Width. The final approach area is centered on the extended runway centerline. The area has a total width of 1,000 feet at the point 200 feet from the threshold and expands uniformly to a total width of 16,000 feet at a point 50,000 feet from the point of beginning. This width further expands uniformly where a greater length is required as in paragraph 1020b(1). See figure 98. The width either side of the centerline at a given distance "D" from the point of beginning can be found by using the formula 1/2W = 500 + D.15D. 500 + .15 x 50,000 = 8,000, which is ½ the width. Therefore, the total width is 16,000 feet at the 50,000 foot point.

NOTE: Where glide slope interception occurs at a distance greater than 50,200 feet from the threshold, the final approach area and the final approach surface may be extended symmetrically to a maximum distance dictated by the usability of the glide slope.

1021. FINAL APPROACH OCS. The final approach OCS is an inclined plane which originates at the runway THR elevation, 975 feet before GPI, and overlies the final approach area. The surface is divided into two sections: an inner 10,000 foot section and an outer 40,000 foot section. The slope of the surface changes at the 10,000 foot point. The exact gradient differs according to the angle at which the glide slope is established (see figure 98A). Paragraphs 1024 and 1025 address application of the OCS.

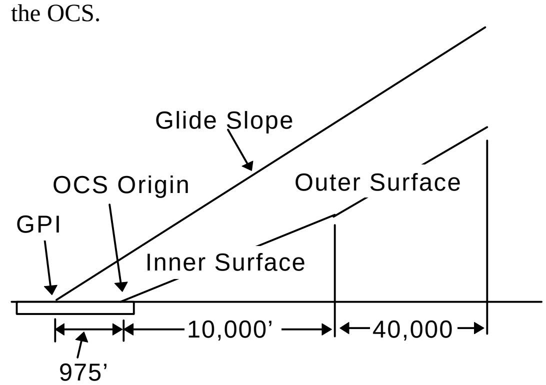


Figure 98A. OBSTACLE CLEARANCE SURFACES. Par 1021.

1022. TRANSITIONAL SURFACE. Transitional surfaces for **PAR** are inclined planes with a slope of 7:1 which extend outward and upward from the edges of the final approach area, starting at the height of the applicable final approach surface and extending for a lateral distance of 5,000 feet at right angles to the runway centerline. (see figure 98).

1023. DELETED.

1024. OBSTACLE CLEARANCE. No obstacle shall penetrate the applicable final approach OCS specified in paragraph 1021 or the transitional surfaces specified in paragraph 1022. Compare obstacle height to the appropriate OCS/transitional surface using the formulae below.

a. Inner OCS. Calculate the height of the inner OCS (OCS_I) at any distance D less than 10,975 feet from GPI using the following formula:

$$OCS_I \text{ Height Above THR } = \left[\left(\tan(gs) - 0.02366\right) \times D\right] - 20$$

where: gs = glide slope angle
D = distance from GPI in feet

b. Outer OCS. Calculate the height of the outer slope (OCS_O) at any distance D equal to or greater than 10,975 feet from GPI using the following formula:

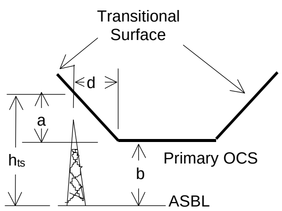
$$OCS_O \text{ Height Above THR } = \left[\left(\tan(gs) - 0.01866\right) \times D\right] - 75$$

where: gs = glide slope angle
D = distance from GPI in feet

c. Transitional Surface. Calculate the height of the transitional surface (h_{ts}) at any distance (d) from the edge of the primary area measured perpendicular to the final approach course using the following formula.

(1) $a = \frac{d}{7}$

(2) $h_{ts} = a + b$



Where a = amount of surface adjustment
d = distance from edge of primary
b = OCS_I or OCS_O as appropriate

1025. EFFECT OF OBSTACLES INSIDE THE DH. See paragraph 251 for the assessment of the visual portion of a PAR approach.

1026. GLIDE SLOPE. In addition to the required obstacle clearance, the following shall apply to the selection of the glide slope angle and antenna location.

a. Glide Slope Angle. The optimum glide slope angle is 3§. Angles less than 2§ or more than 3§ shall not be established without the authorization of the approving authority. The PAR glide slope angle shall be within 0.20 of the non-radar precision instrument approach/VGSI glide slope angle and the RPI shall be within plus or minus 50 feet (30 feet for PAPI and PVGSI) of the non-radar precision approach RPI and/or VGSI runway reference point (RRP).

b. Glide Slope Threshold Crossing Height (TCH). See paragraph 980 for TCH requirements. A height as low as 32 feet for military airports may be used at locations where special consideration of the glidepath angle and antenna location are required. Where the glide slope TCH exceeds 60 feet, consider relocating the landing threshold to ensure effective placement of the approach light system. See appendix 2 for a method of computing TCH.

1027. RELOCATION OF GLIDE SLOPE. Where the OCS associated with a 3° glide slope is penetrated, and sufficient length of runway is available, the glide slope may be moved the required distance down the runway to ensure the OCS is clear. Where the glide slope threshold crossing height exceeds 60 feet, consider relocating the landing threshold to ensure effective placement of the approach light system. The minimum distance between the GPI and the runway threshold is 775 feet. (No minimum GPI distance need be applied to military locations provided the OCS is clear and TCH standards are met.)

1028. DECISION HEIGHT (DH). Paragraph 938 applies.

1029. RESERVED.

SECTION 3. PAR MISSED APPROACH

1030. MISSED APPROACH SEGMENT. The MAP begins at the missed approach point and ends at an appropriate point or fix where initial approach or en route obstacle clearance is provided. Missed approach procedures shall be based on positive course guidance where possible.

1031. MISSED APPROACH POINT (MAP). The MAP is a point on the final approach course where the height of the glide slope is equal to the authorized DH.

1032. STRAIGHT MISSED APPROACH. The straight missed approach area (maximum of 15§ turn from FAC) starts at the MAP. The length of the area is 15 miles measured along the missed approach course. The area has a width equal to that of the final approach area at the MAP and a width equal to that of the initial approach area at a point 15 miles from the MAP. The missed approach area is divided into 2 sections.

a. Section 1 starts at the MAP and is longitudinally centered on the missed approach course. It has the same width at the MAP as the final approach area.

CHAPTER 15. AREA NAVIGATION (RNAV)

1500. GENERAL. This chapter applies to instrument procedures based on ~~airborne~~ area ~~RNAV~~navigation systems. Separate criteria are presented for VOR/DME and non-VOR/DME RNAV systems.

a. VOR/DME Systems. This includes systems using signals based solely upon VOR/DME, VORTAC, and TACAN facilities. VOR/DME is synonymous with the terms VORTAC or TACAN.

b. Non-VOR/DME Systems.

(1) Self-contained systems, including inertial navigation system (INS) and Doppler.

(2) ~~**Other ground-based systems, such as**~~ **Loran-C**, **Omega** and~~,~~ Rho-Rho~~, etc.~~ ground-based systems.

(3) Multi-sensor systems.~~;~~ T~~t~~hose which use a combination of input information.

1501. TERMINOLOGY. The following terms, peculiar to RNAV procedures, are defined as follows:

a. APT WP. A WP located on the FAC at or abeam the first usable landing surface, which is used for construction of the final approach area for a circling-only approach. (LORAN circling approaches only).

b. A~~TD~~longtrack Distance (ATD) ~~Fix~~. The ATD fix is an alongtrack (ATRK) position defined as a distance in NM, with reference to the next WP.

c. ATRK Fix Displacement Tolerance. Fix displacement tolerance along the flight track.

d. Crosstrack (XTRK) Fix Displacement Tolerance. Fix displacement tolerance to the left or right of the flight track.

e. Instrument Approach Waypoint. Fixes used in defining RNAV IAP's, including the feeder waypoint (FWP), the initial approach waypoint (IAWP), the intermediate waypoint (IWP), the final approach waypoint (FAWP), the RWY WP, and the APT WP, when required.

f. Non-VOR/DME RNAV is not dependent upon a reference facility and will hereinafter be referred to as non-VOR/DME, which includes the following:

(1) Long-Range Navigation (Loran-C). Loran-C is a long-range radio navigation system. A Loran-C "chain" consists of four transmitting facilities, a master and three secondaries, each transmitting in the same group repetition interval (GRI).

(2) Omega. A low frequency ~~(LF)~~ navigation system using precise timed pulsed signals from eight ground transmitting stations spaced long distances apart. Limited to en route~~en-route~~ only.

(3) Inertial Navigation System (INS). A self-contained system which utilizes gyros to determine angular motion and accelerometers to determine linear motion. They are integrated with computers to provide several conditions which include true heading, true air speed ~~(TAS)~~, wind, ~~GP~~a glidepath, velocity, and position.

(4) Doppler. ~~.~~ A self-contained system which determines velocity and position by the frequency shift of a signal transmitted from the aircraft and reflected from the surface back to the aircraft.

(5) Global Positioning System (GPS). A system of satellites providing three-dimensional position and velocity information. Position and velocity information is based on the measurement of the transit time of radio frequency (RF) signals from satellites.

(6~~5~~) Rho-Rho. A system based on two or more DME ground facilities.

(7~~6~~) Multi-Sensor System. Based on any VOR/DME or non-VOR/DME certified approved system or a combination of certified approved systems. The non-VOR/DME criteria apply.

g. Reference Facility. A VOR/DME, VORTAC or TACAN facility used for the identification and establishment of an RNAV route, WP, or SIAP.

h. RNAV Descent Angle. A vertical angle defining a descending flightpath from the FAF to the RWY WP.

i. Routes. Two subsequently related WP's or ATD fixes define a route segment.

(1) Jet/Victor Routes.

(2) Random Routes. Any airway not established under the jet/victor designation. This is normally used to refer to a route that is not based on VOR radials and requires an RNAV system.

j. RWY WP. A WP located at the runway threshold and used for construction of the final approach area when the FAC meets straight-in alignment criteria.

k. Tangent Point (TP). The point on the VOR/DME RNAV route centerline from which a line perpendicular to the route centerline would pass through the reference facility.

l. Tangent Point Distance (TPD). Distance from the reference facility to the TP.

m. Time Difference (TD) Corrections. Loran-C systems use the time of signal travel from ground facilities to the aircraft to compute distance and position. The time of signal travel varies seasonally within certain geographical areas. The TD correction factor is used to correct these seasonal variations for each geographical area. RNAV criteria assume local TD corrections will be applied.

n. Turn Anticipation. The capability of RNAV systems to determine the point along a course, prior to a turn WP, where a turn should be initiated to provide a smooth path to intercept the succeeding course, and to enunciate the information to the pilot.

o. Turn WP. A WP which identifies a change from one course to another.

p. VOR/DME RNAV is dependent on VOR/DME, VORTAC, or TACAN. It is a system using radials and distances to compute position and flight track and will hereinafter be referred to as VOR/DME.

q. WP. A predetermined geographical position used for route definition and~~/or~~ progress reporting purposes that is defined by latitude/longitude. For VOR/DME systems, it is defined ~~also~~ by the radial/distance of the position from the reference facility.

r. WP Displacement Area. The rectangular area formed around and centered on the plotted position of a WP. Its dimensions are plus-and-minus the appropriate ATRK and XTRK fix displacement tolerance values which are found in tables 15-1, 15-2, and 15-3.

1502. PROCEDURE CONSTRUCTION. RNAV procedural construction requirements are as follows:

a. Reference Facility. An RNAV approach procedure shall be supported by a single reference facility.

b. WP. A WP shall be used to identify the point at which RNAV begins and the point at which RNAV ends, except when the RNAV portion of the procedure terminates at the MAP, and the MAP is an ATD fix.

c. Segment. Approach segments begin and end at the WP or ATD fix.

~~–~~**(1) The segment area** considered for obstacle clearance begins at the earliest point the WP or ATD fix can be received and, except for the final approach segment, ends at the plotted position of the fix.

~~–~~**(2) Segment length** is based on the distance between the plotted positions of the WP or ATD fix defining the segment ends.

~~–(~~**(3) Segment widths** are specified in appropriate paragraphs of this chapter, but in no case will they be narrower than XTRK fix displacement tolerances for that segment.

~~–~~**(4) Minimum segment widths** are also determined/limited in part according to WP location relative to the reference facility. This limiting relationship is depicted in figure 15-2 and explained in the note following figure 15-2.

d. Fix Displacement. Except in the case of the MAP overlapping the RWY WP or APT WP (see paragraph 1532), the ATRK fix displacement tolerance shall not overlap the plotted position of the adjacent fix. Additionally, except for a turn at a MAP designated by a WP, WP displacement tolerances shall be oriented along the courses leading to and from the respective WP (s~~.~~ ~~S~~ee figure 15-17).

e. Turning Areas. Turning area expansion criteria shall be applied to all turns, en route~~en-route~~ and terminal, where a change of direction of more than 15° is involved. See paragraphs 1510c and 1520.

f. Cone of Ambiguity. The primary obstacle clearance area at the minimum segment altitude shall not be within the cone of ambiguity of the reference facility. If the primary area for the desired course lies within the cone of ambiguity, the course should be relocated or the facility flight inspected to verify that the signal is adequate within the area. FAA Order 9840.1, U.S. National Aviation Handbook for the VOR/DME/ TACAN Systems, defines the vertical angle coverage. Azimuth signal information permitting satisfactory performance of airborne components is not provided beyond the following ranges:

~~–~~**(1) VOR** - beyond 60° above the radio horizon.

–**(2) TACAN** - beyond 40° above the radio horizon~~.~~ (s~~S~~ee figure 15-1).

g. Use of ATD Fixes. ATD fixes are normally used in lieu of approach WP's when no course change is required at that point. An ATD fix shall not be used in lieu of a RWY WP. The FAF, MAP, and any stepdown fixes may be defined by ATD -fixes.

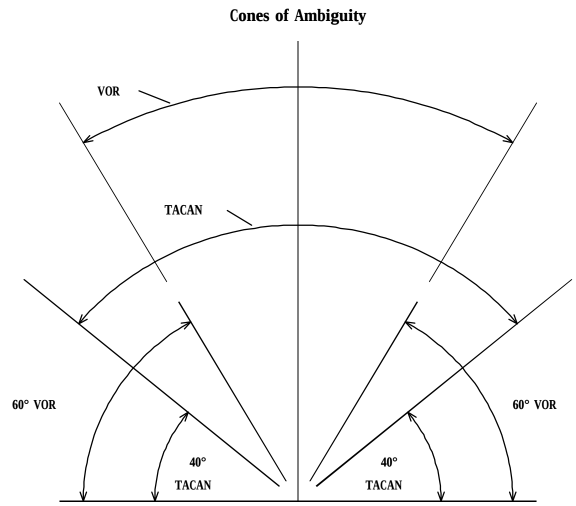
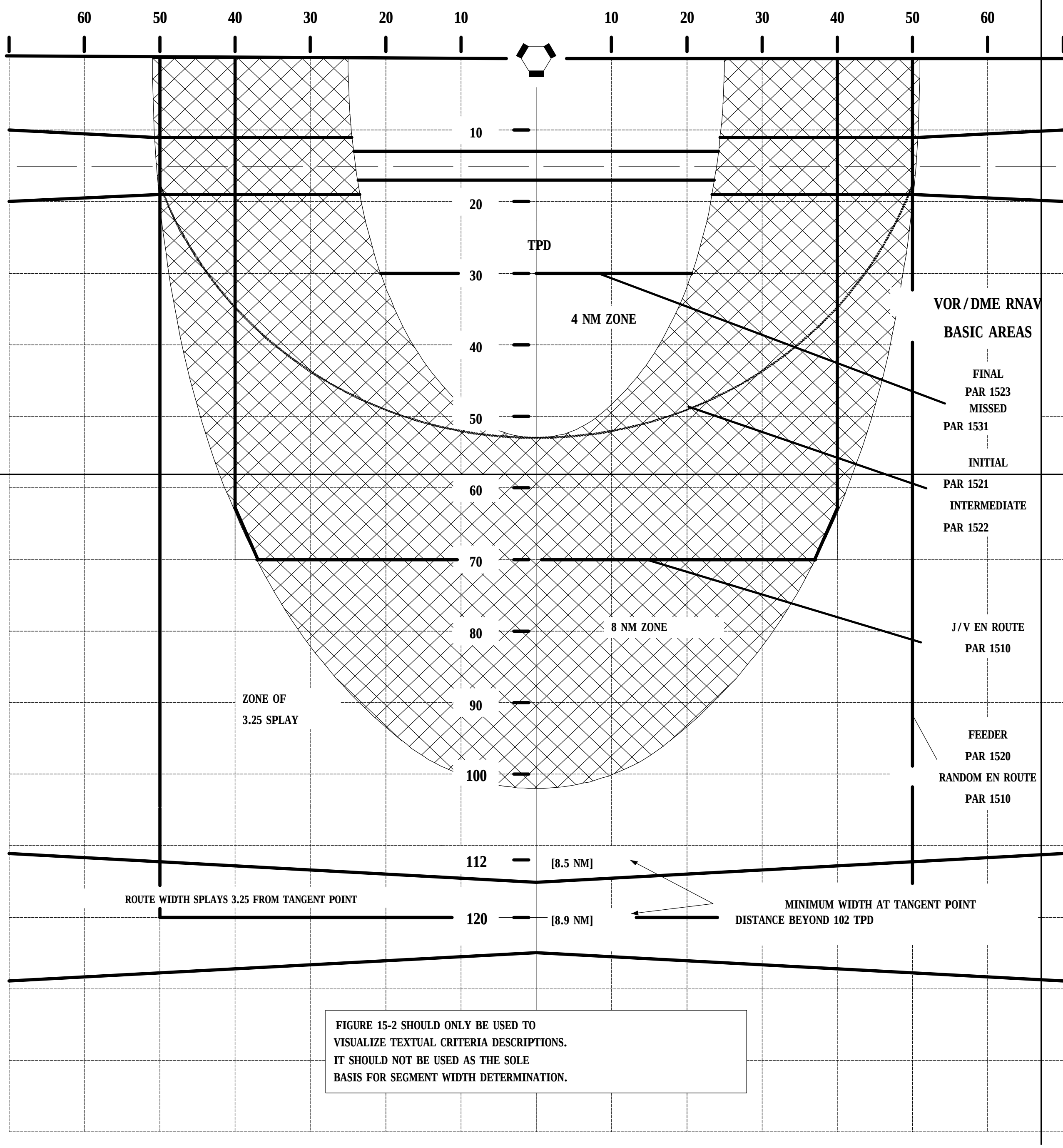


Figure 15-1. CONES OF AMBIGUITY.
Par 1502.~~Paragraph 1502.~~

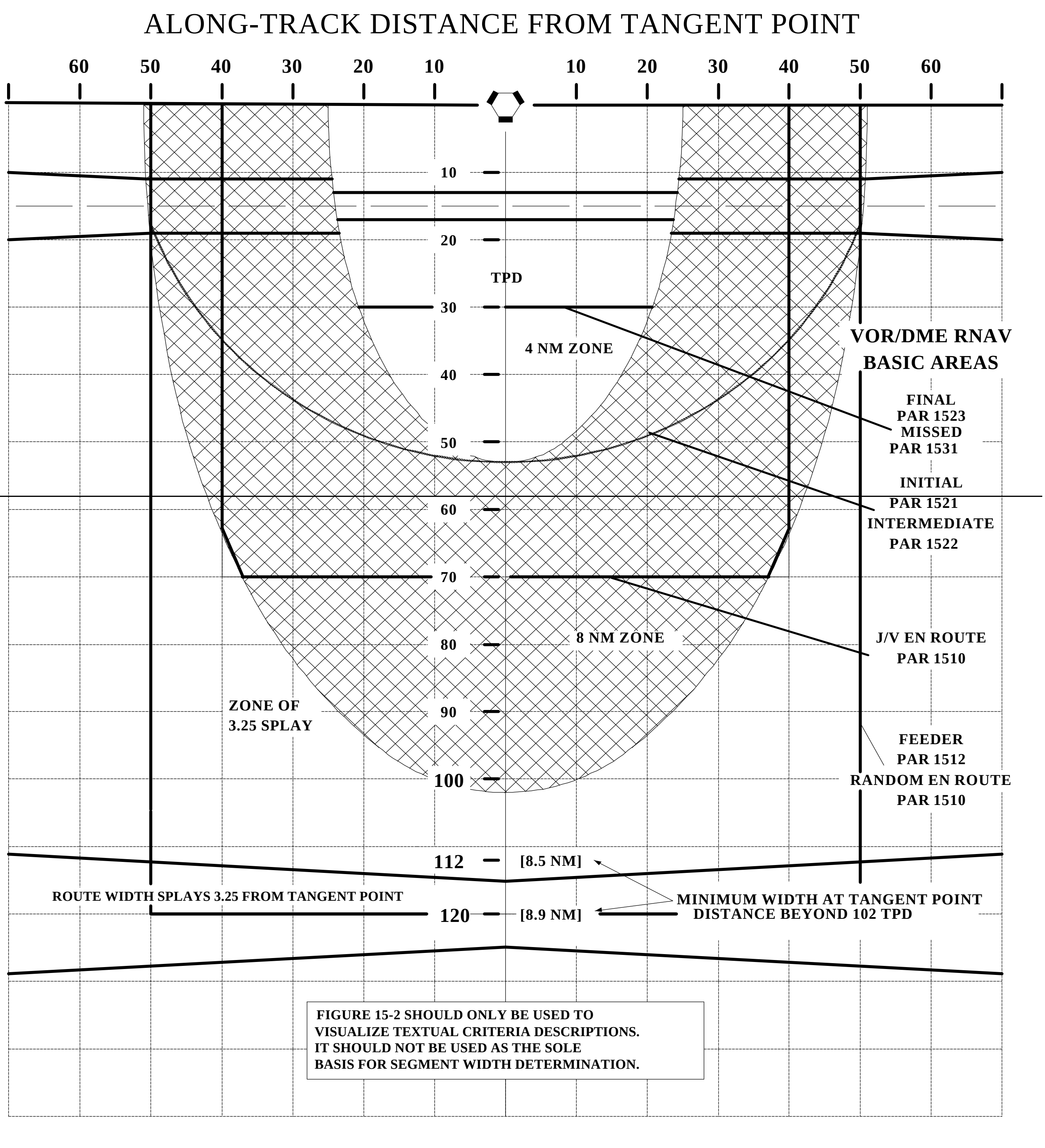
~~Figure 15-2~~
~~Paragraph 1502~~

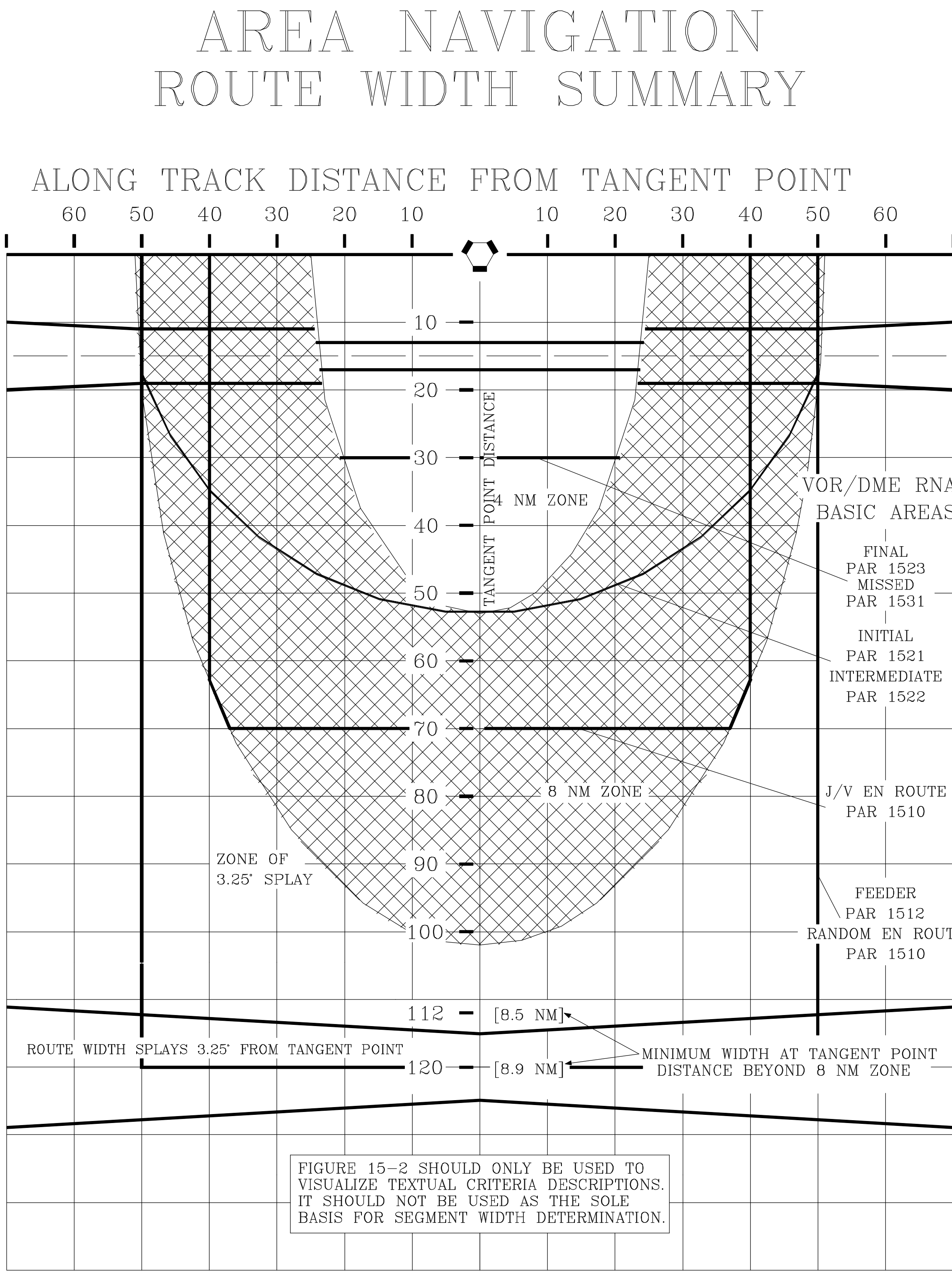
AREA NAVIGATION
ROUTE WIDTH SUMMARY

DISTANCE ALONG-TRACK FROM TANGENT POINT



AREA NAVIGATION
ROUTE WIDTH SUMMARY





~~Figure 15-2~~
~~Paragraph 1502~~
Figure 15-2. Par 1502.

NOTE: Segment width (for instance at a specific WP) is based upon a mathematical relationship between TPD, and the ATD from the TP, at that point. This relationship is represented by the two elliptical curves shown on figure 15-2. One curve encloses the "4 NM ZONE" wherein the segment primary area width is ± 2 miles from route centerline. The other curve encloses the "8 NM ZONE" wherein the segment primary area width is ± 4 miles from route centerline.

The formula for the 4 NM ZONE curve is: $\cancel{\frac{X^2}{(51)^2}+\frac{Y^2}{(102)^2}=1}\ \underline{\frac{X^2}{(25.5)^2}+\frac{Y^2}{(53)^2}=1}$

The formula for the 8 NM ZONE curve is: $\cancel{\frac{X^2}{(25.5)^2}+\frac{Y^2}{(53)^2}=1}\ \underline{\frac{X^2}{(51)^2}+\frac{Y^2}{(102)^2}=1}$

where X = ATD from the TP
and, Y = TPD

APPLICATION:

——4 NM ZONE: To determine the maximum acceptable ATD value associated with a given TPD value and still allow segment primary width at ± 2 miles.

Given: TPD = 40 miles (this is the Y-term)
Find: ATD value (this is the X-term)

$$X=25.5\sqrt{1-\frac{Y^2}{(53)^2}}$$

$$X=25.5\sqrt{1-\frac{(40)^2}{(53)^2}}=16.73 \text{ miles}$$

—i.e., for TPD at 40 miles, if the ATD exceeds 16.73 miles, the primary area width must be expanded to ± 4 miles.

——8 NM ZONE: Given: ATD = 30 miles
—Find: TPD Maximum for ± 4 miles width

$$Y=102\sqrt{1-\frac{X^2}{(51)^2}}$$

$$Y=102\sqrt{1-\frac{(30)^2}{(51)^2}}=82.49 \text{ miles}$$

i.e., for ATD at 30 miles, the TPD must not exceed 82.49 miles and still allow ± 4 miles width.

APPLICATION: The formulas can tell you whether the specific point is inside or outside either zone area. For instance:

Given: ATD = 40 miles, and TPD = 65 miles. Determine if the location is within the 8 NM ZONE.

The basic formula for the 8 NM ZONE is an equation made equal to 1. By substituting the specific values (ATD = 40, and TPD = 65), the point will be determined to be OUTSIDE the zone if the resultant is > 1, and INSIDE the zone if the resultant is < or = to 1.

$$\frac{X^2}{(51)^2}+\frac{Y^2}{(102)^2}=1$$

by substitution:

$$\frac{(40)^2}{(51)^2}+\frac{(65)^2}{(102)^2}=0.615+0.406=1.021$$

Since this is >1, the point lies OUTSIDE the 8 NM ZONE.

For distances beyond 102 miles of the TPD, the route width expands an additional 0.25 miles each side of the route centerline for each 10 miles the TPD is beyond 102 miles.

Example: 112 NM-102 NM = 10 NM beyond 102 TPD.

a. (10 NM/10 NM) X .25 NM (rate per 10 NM) = 0.25 increase.

b. 0.25 NM + 4 NM = 4.25 NM each side centerline.

c. 4.25 X 2 = 8.5 NM (total width) at the 112 TPD.

h. PCG. All RNAV segments shall be based on PCG, except that a missed approach segment without PCG may be developed when considered to provide operational advantages and can be allowed within the obstacle environment.

1503. RESERVED.

1504. REFERENCE FACILITIES. Reference facilities shall have collocated VOR and DME components. For terminal procedures, components within 100 feet of each other are defined as collocated. For en route~~en route~~ procedures, components within 2,000 feet of each other are defined as collocated.

1505. WP's. RNAV WP's are used for navigation reference and for ATC operational fixes, similar to VOR/DME ground stations, and intersections used in the conventional VOR structures.

a. Establishment. WP's shall be established along RNAV routes at the following points:

(1) At end points.~~;~~

(2) At points where the route changes course.~~;~~

(3) At holding fixes.~~; and,~~

(4) At other points of operational benefit, such as route junction points which require clarity.

~~**(4) At other points of operational benefit,** such as route junction points which require clarity.~~

(5) For VOR/DME WP's, one WP must be associated with each reference facility used for en route~~en-route~~ navigation requirements. If a segment length exceeds 80 miles and no turning requirement exists along the route, establish a WP at the TP.

b. WP. WP placement is limited by the type of RNAV system as follows:

(1) ~~No~~ VOR/DME WP's or route segments shall not be established outside of the service volume of the reference facility and shall be limited to the values contained in tables 15-1 and 15-2.

(2) N~~o~~ ~~n~~on-VOR/DME WP's or route segments shall not be established outside of the area in which the particular system signal has been approved for IFR operation.

(3) Self-contained systems such as INS and Doppler do not have limitations on WP placement.

(4) Fix Displacement Tolerances. Tables 15-1 and 15-2 show fix displacement tolerances for VOR/DME systems. Table 15-3 shows fix displacement tolerances for non-VOR/DME systems. When the fix is an ATD fix, the ATRK fix and XTRK displacement tolerances are considered to be the same as a WP located at that fix.

c. Defined WP Requirements.

(1) VOR/DME WP's. Each WP shall be defined~~d~~ by:

(a) A VOR radial - developed to the nearest hundredth of a degree.~~;~~

(b) DME distance - developed to the nearest hundredth of a mile; and

(c) Latitude/longitude - in degrees, minutes, and seconds to the nearest hundredth.

(2) Non-VOR/DME WP's. Each WP shall be defined by latitude and longitude in degrees, minutes, and seconds developed to the nearest hundredth. Rho-Rho WP's shall also be developed to the nearest hundredth of a mile.

(3) Station elevation of the reference facility shall be defined and rounded to the nearest 20-foot increment.

1506. RWY WP AND APT WP. Straight-in procedures shall incorporate a WP at the runway threshold. Circling procedures shall incorporate an APT WP at or abeam the first usable landing surface. See figure 15-3. These WP's are used to establish the length and width of the final approach area.

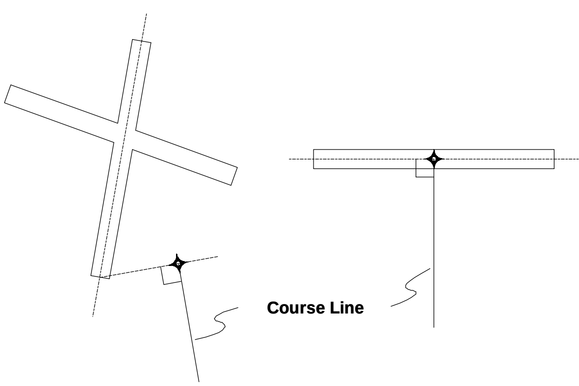


Figure 15-3. LOCATION OF APT WP~~AIRPORT WP~~.
Para~~graph~~ 1506.

1507. HOLDING. Chapter 2, section 9, applies, except for paragraph 292d. When holding is at an RNAV fix, the selected pattern shall be large enough to contain the entire area of the fix displacement tolerance within the primary area of the holding pattern.

a. VOR/DME Pattern Size Selection. For VOR/DME, the distance from the WP to the reference facility shall be applied as the "fix-to-NAVAID distance" in FAA Order 7130.3, Holding Pattern Criteria, figure 3, pattern-template selection.

b. Non-VOR/DME Pattern Size Selection. For non-VOR/DME, use the 15-29.9 NM distance column for terminal holding procedure, and 30 NM or over column for en~~-~~ route holding, FAA Order 7130.3.

1508.-1509. RESERVED.

SECTION 1. EN~~-~~ R~~R~~OUTE CRITERIA.

1510. EN~~N-~~ ROUTE OBSTACLE CLEARANCE AREAS. En~~-~~route obstacle clearance areas are identified as primary and secondary. These designations apply to straight and turning segment obstacle clearance areas. The required angle of turn connecting en route~~en-route~~ segments to other en~~-~~route, feeder, or initial approach segments~~,~~ shall not exceed 120°. Where the turn exceeds 15°, expanded turning area construction methods in paragraph 1510c apply.

a. Primary Area. The primary obstacle clearance area is described as follows:

(1) VOR/DME Basic Area. The area is 4 miles each side of the route centerline, when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The ~~route~~ width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centerline lies outside the 8 NM zone. See figure 15-4. When the TPD exceeds the 102-mile limit, the minimum width at the TPD expands greater than ± 4 miles at a rate of 0.25 miles on each side of the route for each 10 miles the TPD is beyond 102 miles. See figures 15-2, 15-5, and table 15-1. When the widths of adjoining route segments are unequal for reasons other than transition of zone boundaries, the following apply:

(a) If the TP of the narrower segment is on the route centerline, the width of the narrower segment includes that additional airspace within the lateral extremity of the wider segment, where the route segments join, thence toward the TP of the narrower route segment until intersecting the boundary of the narrower segment (s~~. S~~ee figure 15-6).

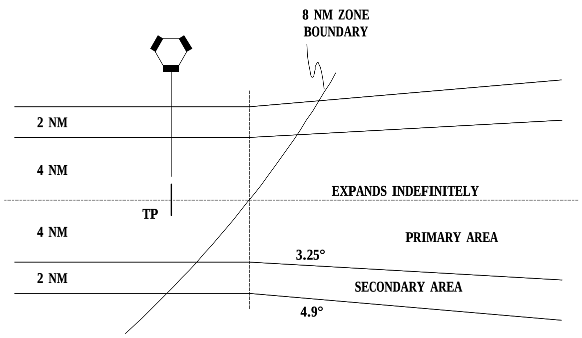


Figure 15-4. VOR/DME BASIC AREA.
Par 1510a(1)

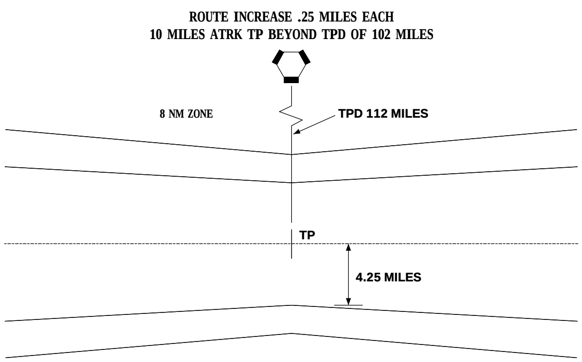


Figure 15-5. VOR/DME BASIC AREA.
Para~~graphs~~ 1510a(1) and b(1).

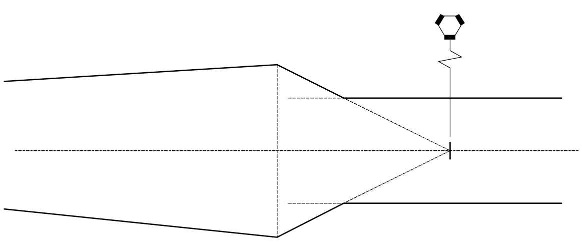


Figure 15-6. UNEQUAL JOINING ROUTE SEGMENTS. Para~~graph~~ 1510a(1)(a).

(b) If the TP of the narrower segment is on the route centerline extended, the width of the narrower segment includes that additional airspace within lines from the lateral extremity of the wider segment where the route segments join, thence toward the TP until reaching the point where the narrower segment terminates, changes direction, or until intersecting the boundary of the narrower segment (s~~. S~~ee figure 15-7).

(2) Non-VOR/DME Basic Area. The area is 4 miles each side of the route centerline at all points. Non-VOR/DME primary boundary lines do not splay.

(3) Termination Point. An RNAV route termination point shall be at a WP. The primary area extends beyond the route termination point. The boundary of the area is defined by an arc which connects the two primary boundary lines. The center of the arc is located at the most distant point on the edge of the WP displacement area on the route centerline (s~~. S~~ee figure 15-8).

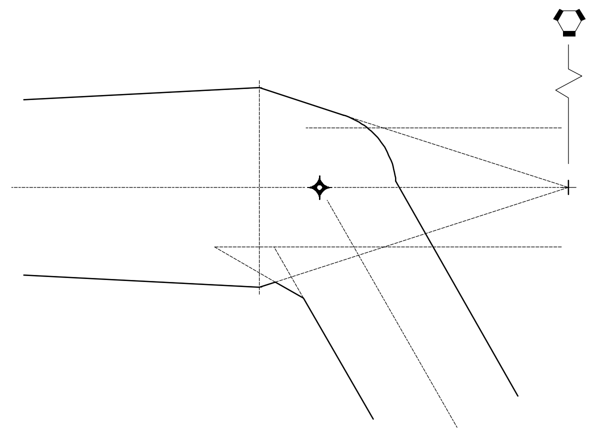


Figure 15-7. UNEQUAL JOINING ROUTE SEGMENTS WITH A TURN.
Para~~graph~~ 1510a(1)(b).

b. Secondary Areas.

(1) VOR/DME Basic Area. The VOR/DME secondary obstacle clearance area extends 2 miles on each side of the primary area and splays 4.9° where the primary splays at 3.25°. See figure 15-4. The secondary area beginning width does not increase beyond the 102-mile TPD.

(2) Non-VOR/DME Basic Area. The non-VOR/DME secondary obstacle clearance areas are a constant 2-mile lateral extension on each side of the primary area.

(3) Termination Point. The secondary obstacle clearance area extends beyond the arc which defines the termination point primary area by an amount equal to the width of the secondary area at the latest point the WP can be received (s~~. S~~ee figure 15-8).

c. Construction of Expanded Turning Areas. Obstacle clearance areas shall be expanded to accommodate turns of more than 15°. The primary and secondary obstacle clearance turning areas are expanded by outside and inside areas (s~~. S~~ee figure 15-9). The inside expansion area is constructed to accommodate

~~expansion area is constructed to accommodate~~ a turn anticipation area. Outside expansion area is provided to accommodate overshoot at high speeds and excessive wind conditions. No portion of the primary area at the minimum segment altitude may be in the cone of ambiguity for VOR/DME RNAV routes.

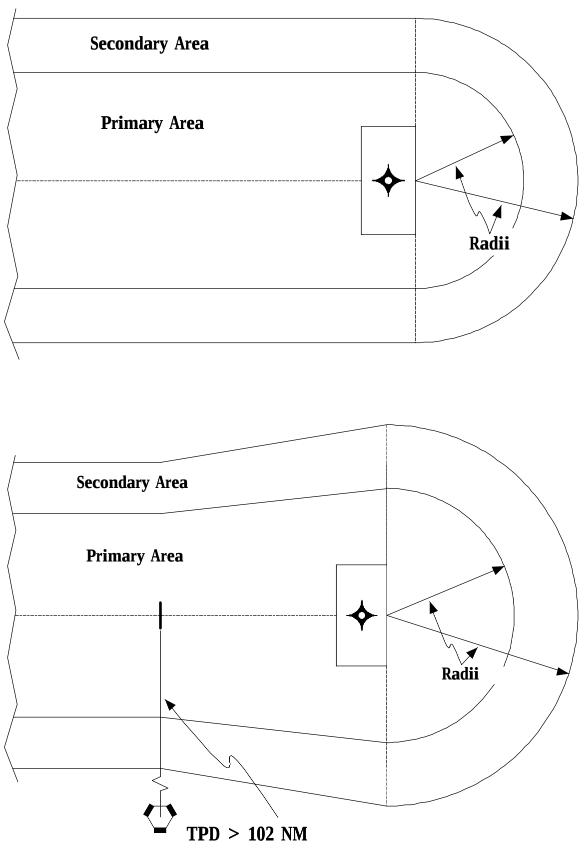


Figure 15-8. TERMINATION POINTS. Par~~agraphs~~ 1510a(3) and 1510b(3).

(1) Outside Expansion Area. Determine the expanded area at the outside of the turn as follows:

(a) Construct a line perpendicular to the route centerline 3 miles prior to the latest point the fix can be received or to a line perpendicular to the route centerline at the plotted position of the fix, whichever occurs last. For altitudes 10,000 feet or greater, construct a line perpendicular to the plotted position of the fix. This perpendicular line is a base line for constructing arc boundaries.

(b) From a point on the base line, strike an 8-mile arc from the outer line of the fix displacement area on the outside of the turn to a tangent line to a second 8-mile arc. The second arc is struck from a point on the base line inside the inner line of the fix displacement area to a 30° tangent line to the primary boundary line. From a point where an extension of the base line intersects the primary area outer boundary line, connect the 8-mile arc with a line tangent to the arc.

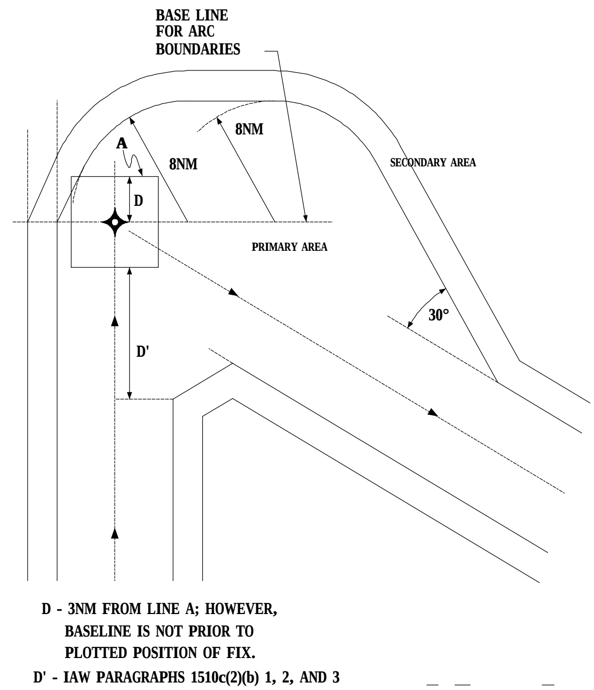


Figure 15-9. EXPANDED TURNING AREAS. Par~~agraph~~ 1510c.

(c) Strike arcs from the center points used for the primary area expansion and provide a parallel expansion of 2 miles of the secondary area at the turn.

(d) Connect the extremities with a straight-line tangent to the two associated arcs.

(e) Draw the remaining secondary area boundary 2 miles outside the boundary of the primary area.

(f) If the width of the primary area at the turn point is greater than 8 miles, the expanded area is constructed in the same manner, as outlined in paragraph 1510c(1), using the primary area width at the point where the route changes course as the radius of the arc in place of 8 NM and constructing the secondary area of constant width equal to the width of the secondary area at the turn point.

(2) Inside Expansion Area. Determine the expanded area at the inside of the turn as follows:

(a) Determine the fix area by application of the ATRK and XTRK fix displacement tolerances.

(b) Prior to the earliest point the WP (oriented along the course leading to the fix) can be received, locate a point on the primary area boundary at one of the following distances:

1 Three miles below 10,000 feet MSL; three and one-half miles when the turn exceeds 112°.

2 Seven miles for 10,000 feet MSL up to but not including FL 180.

3 Twelve miles for FL 180 and above.

(c) From this point, splay the primary area by an angle equal to one-half of the course change.

(d) Draw the secondary area boundary 2 miles outside the boundary of the primary area.

d. TPD/WP Limitation. WP's for the Jet/Victor Airway structure shall be limited to the 8 NM zone, a TPD of 70 miles or less, and an ATD fix from the TP of 40 miles or less. WP's for random airway structure shall be limited to a TPD of 120 miles or less and an ATD fix from the TP of 50 miles.

e. Joining RNAV with n~~N~~on-RNAV Route Segments.

(1) If the RNAV and non-RNAV segments have the same width at the point of transition, the segments are joined at that location and RNAV criteria are continued in the direction of the RNAV segment.

(2) If the RNAV segment is narrower at the location of the transition, the segments shall be joined according to paragraph 1512b(1)(b).

~~(~~(3) If the RNAV segment is wider at the location of the transition, the boundaries shall taper from the transition location toward the non-RNAV segment at an angle of 30° until joining the boundaries at the RNAV segments. If the location of transition includes a turn, the width of the RNAV segment is maintained and the turn area constructed according to this chapter. After the completion of the turn area, the boundaries shall taper at an angle of 30° until passing the non-RNAV boundaries.

1511. OBSTACLE CLEARANCE. Paragraphs 1720 and 1721 apply, except that the width of the VOR/DME secondary area is 2 miles at the point of splay initiation and the value 236 feet for each additional mile in paragraph 1721 is changed to 176 feet/NM. Non-VOR/DME systems do not splay. Obstacles in the secondary area are measured perpendicular to the course centerline, except for the expanded turn areas. Obstacles in these areas are measured perpendicular to the primary area boundary, or its tangent, to the obstacle.

1512. FEEDER ROUTES. When the IAWP is not part of the en route~~en-route~~ structure, it may be necessary to designate feeder routes from the en route~~en-route~~ structure to another FWP or the IAWP.

a. The required angle of turn for the feeder-to-feeder and feeder-to-initial segment connections shall not exceed 120°. Where the angle exceeds 15°, turning area criteria in section 2 apply. En route vertical and lateral airway obstacle clearance criteria shall apply to feeder routes. The minimum altitudes established for feeder routes shall not be less than the altitude established at the IAWP. WP's for feeder routes shall be limited to a TPD of 120 miles or less and an ATD fix from the TP of 50 miles or less.

b. Obstacle Clearance Areas. Obstacle clearance areas are identified as primary and secondary. These designations apply to straight segment and turning segment obstacle clearance areas.

(1) Primary Area. The primary obstacle clearance area is derived from figure 15-2 and the associated formulas. It is described as follows:

(a) VOR/DME Basic Area. The area is 4 miles each side of the route centerline when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The route width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centerline lies outside the 8 NM zone (s~~. S~~ee figure 15-4). When the TPD exceeds the 102-mile limit, the minimum width at the TP increases at a rate of 0.25 miles on each side of the route centerline for each 10 miles the TPD is beyond 102 miles. Methodology for joining route segments of differing widths is contained in paragraph 1510a(1). See table 15-2.

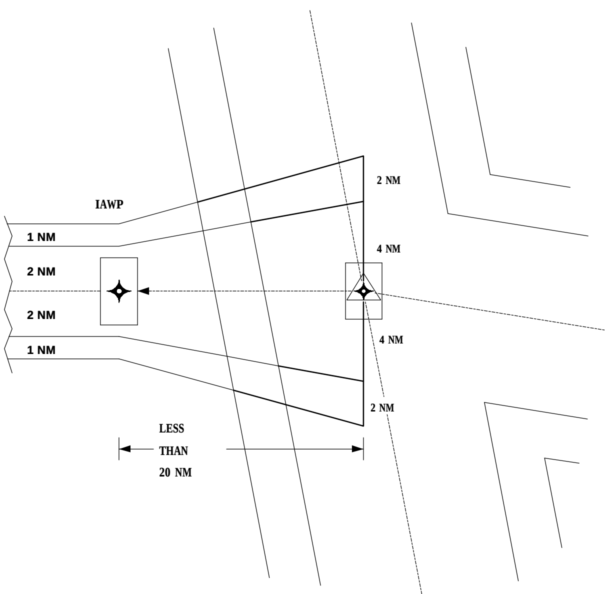
——(b) Non-VOR/DME Basic Area. The area is 4 miles each side of the course centerline at all points, except for the 20-mile portion of the course just prior to the IAWP where it tapers linearly from 4 miles to 2 miles each side of centerline. Where a WP or a fix is located less than 20 miles prior to the IAWP, the taper begins at that point (s~~t. S~~ee figure 15-10).

–**(2) Secondary Areas.**

(a) VOR/DME Basic Areas. Secondary obstacle clearance areas extend laterally 2 miles on each side of the primary area and splay 4.9° in the region where the primary area splays at 3.25°. See figure 15-11 and paragraph 1512b(1)(a).

(b) Non-VOR/DME Basic Area. Non-VOR/DME secondary areas are a constant 2-mile lateral extension on each side of the primary area, except where the basic area tapers as specified in paragraph 1512b(1)(b). Over this area, the secondary area tapers linearly from 2 miles each side of the primary to 1 mile each side of the primary area.

(3) Obstacle Clearance. Paragraph 232c~~220~~ applies.



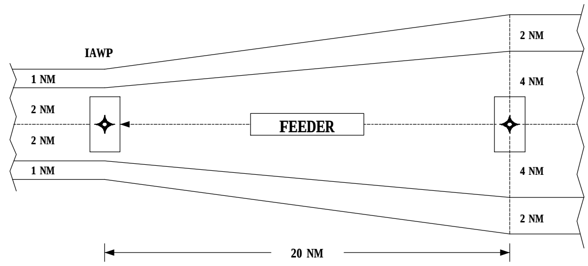


Figure 15-10. FEEDER ROUTES CONNECTING NON-VOR/DME BASIC AREAS. Para~~graph~~ 1512b(1)(b).

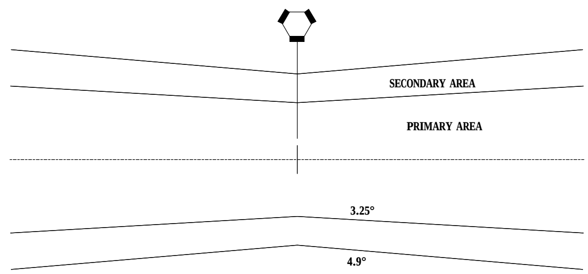


Figure 15-11. VOR/DME SECONDARY AREAS SPLAY 4.9°. Par~~aragraph~~ 1512b(2)(a).

1513-1519. RESERVED.

SECTION 2. TERMINAL CRITERIA.

1520. TERMINAL TURNING AREA EXPANSION. Obstacle clearance areas shall be expanded to accommodate turn anticipation. Outside expansion is not required for terminal procedures. Inside expansion applies to all turns of more than 15° within SIAP's, except turns at the MAP. Paragraph 1534 satisfies early turn requirements for the MAP. Determine the expanded area at the inside of the turn as follows:

a. Determine the ATRK Fix Displacement Tolerance.

b. Locate a point on the edge of the primary area at a distance prior to the earliest point the WP can be received. The distance of turn anticipation (DTA) ~~(distance of turn anticipation)~~ is measured parallel to the course leading to the fix and is determined by the turn anticipation formula:

DTA = 2 x tan (turn angle ÷ 2)

c. From this point, splay the primary area by an angle equal to one-half of the course change (s~~. S~~ee figure 15-12).

d. Secondary Area Boundary:

(1) When the obstacle clearance area boundaries of the preceding and following segments of the WP are parallel with the course centerline, construct the secondary area boundary, parallel with the expanded turn anticipation primary area boundary, using the width of the preceding segment secondary area.

(2) When the obstacle clearance area boundaries of the preceding and/or following segments taper, construct the secondary area boundary by connecting the secondary area at points abeam the primary expansion area where it connects to the preceding/following segments of the primary area boundaries.

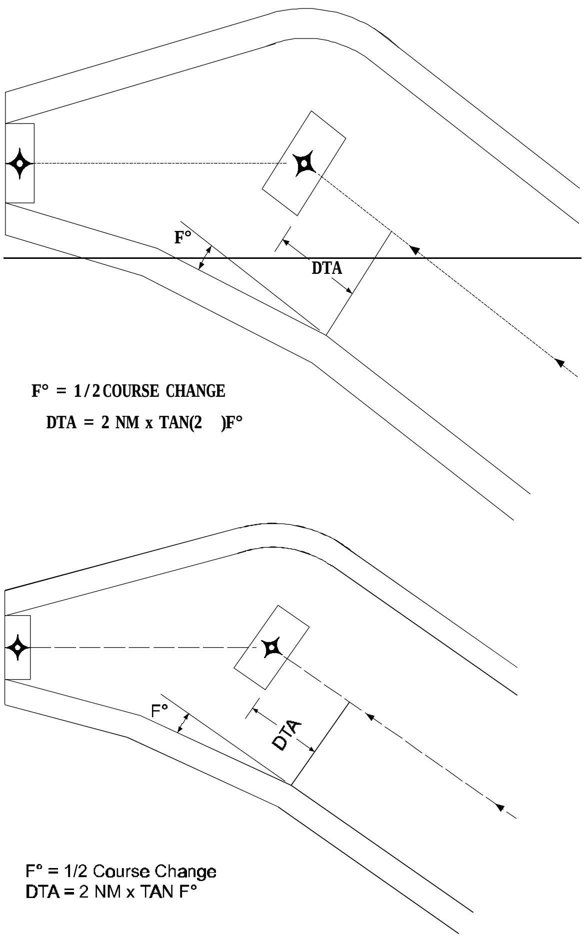


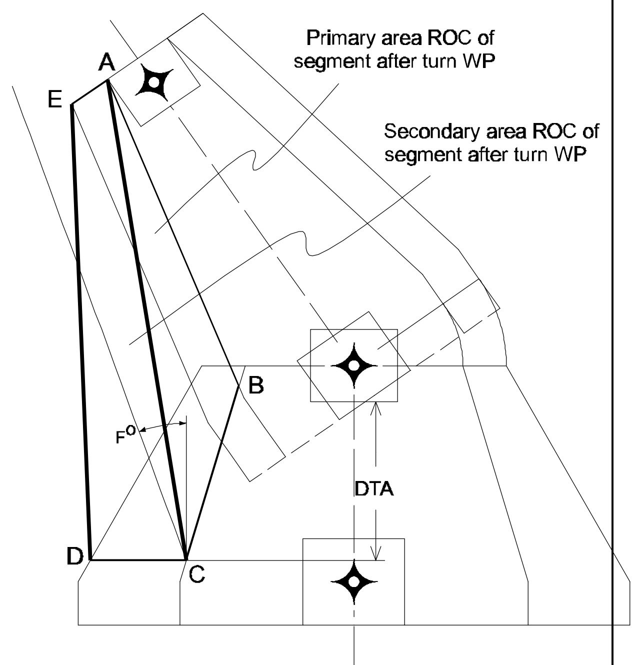
Figure 15-12. TURN ANTICIPATION SPLAY. Par~~agraph~~ 1520.

e. When the boundary of the expanding turn area will not connect with the boundary of the primary area of the following segment, join the expanded area at the boundary abeam the plotted position of the next WP or at the latest reception point of the RWY WP or APT WP, as appropriate (s~~. S~~ee figure 15-13).

f. Obstacle Evaluation of the Expanded Area. Evaluate the primary and secondary expansion areas using the ROC for the segment following the turn WP. See figures 15-13 and 15-14.

1521. INITIAL APPROACH SEGMENT. The initial approach segment begins at the IAWP and ends at the IWP. See figures 15-15, 15-16, and 15-17. For VOR/DME systems, the distance from the reference facility to the IAWP shall not exceed 53 miles, nor exceed the TPD or ATD values associated with the limits of the 8 NM zone (s~~. S~~ee figure 15-2).

a. Alignment. The angle of intercept between the initial and intermediate segment shall not exceed 120°.



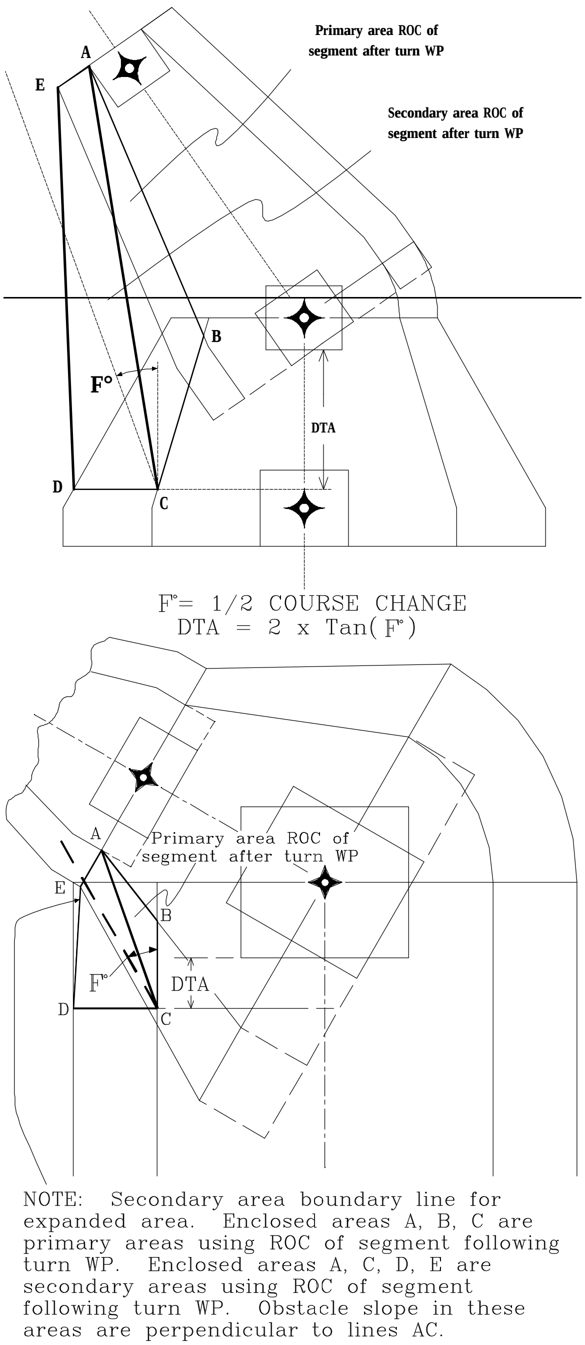


Figure 15-13. SHALLOW-ANGLED TURN ANTICIPATION ILLUSTRATIONS. TAPERING INTERMEDIATE AND CONSTANT WIDTH SEGMENT. ROC APPLICATIONS. Para~~graphs~~ 1520e and f.

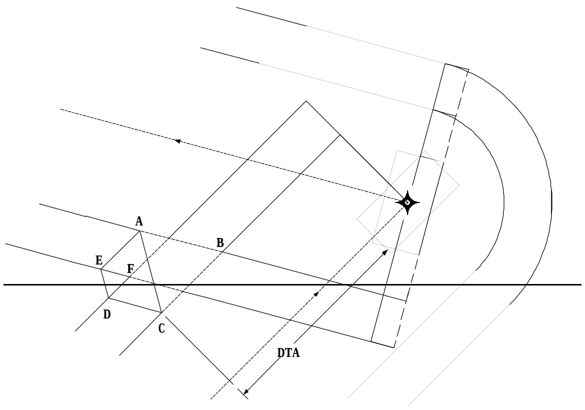
~~NOTE: Secondary area boundary line for expanded area. Enclosed areas A, B, C are primary areas using ROC of segment following turn WP. Enclosed areas A, C, D, E are secondary areas using ROC of segment following turn WP. Obstacle slope in these areas are perpendicular to lines AC.~~

b. Course Reversal. When the procedure requires a course reversal, a holding pattern shall be established in lieu of a PT. If holding is established over the FAF, paragraph 1507 applies. If holding is established over the FAF, the FAF shall be a WP, and paragraph 234e(1) applies. The course alignment shall be within 15° of the FAC. If holding is established over the IWP, paragraph 234e(2) applies. The course alignment shall be within 15° of the intermediate course. Where a feeder segment leads to the course reversal, the feeder segment shall terminate at the plotted position of the holding WP (see figure 15-15).

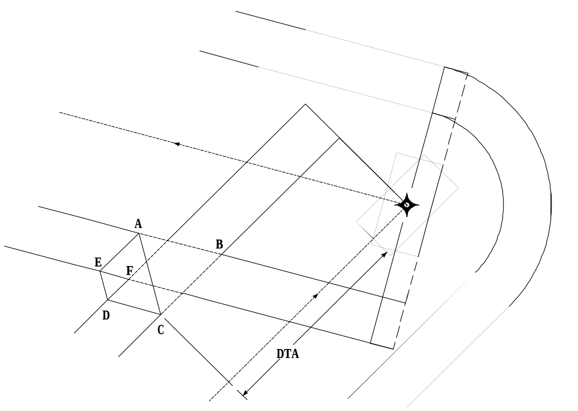
c. Area.

(1) Length. The initial approach segment has no standard length. It shall be sufficient to permit any altitude changes required by the procedure and shall not exceed 50 miles unless an operational requirement exists.

~~lieu of a PT. Paragraph 1507 applies.~~



Enclosed area A, B, C is primary area ROC of segment following turn WP. Area A, C, D, E is secondary area ROC of segment following turn WP. Obstacle slope in this area is perpendicular to line A-C.



Enclosed area A, B, C is primary area ROC of segment following turn WP. Area A, C, D, E is secondary area ROC of segment following turn WP. Obstacle slope in this area is perpendicular to line A-C.

Figure 15-14. TURN ANTICIPATION AREAS. Para~~graph~~ 1520f.

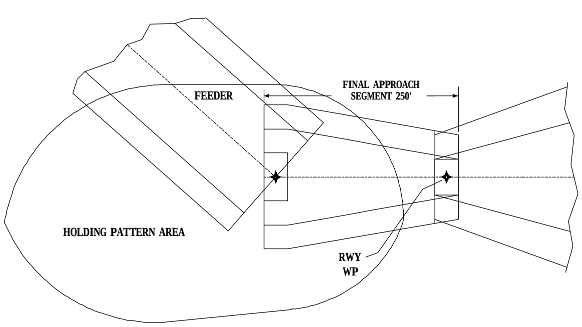


Figure 15-15. HOLDING PATTERN AND FINAL APPROACH, AND ASSOCIATED ROC. Para~~graph~~ 1521b.

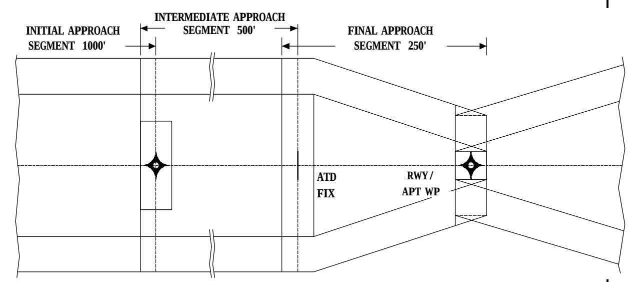


Figure 15-16. INITIAL, INTERMEDIATE, FINAL APPROACH, AND ASSOCIATED ROC. Para~~graphs~~ 1521~~, 1522~~, 1523.

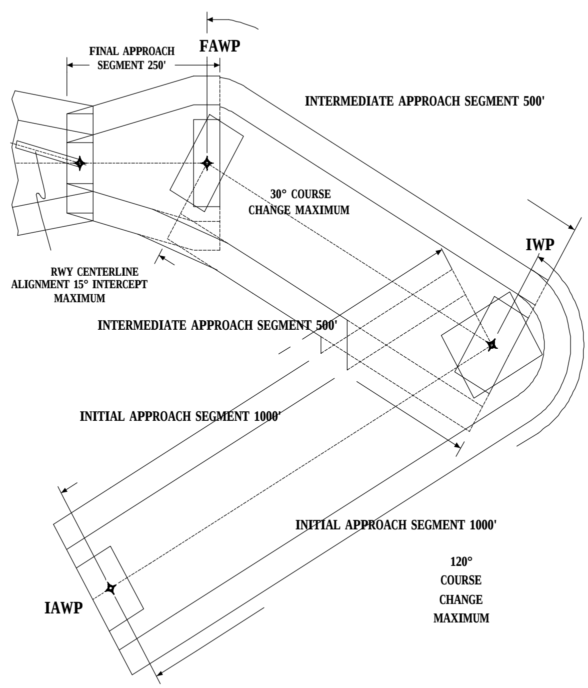


Figure 15-17. INITIAL, INTERMEDIATE, FINAL APPROACH, AND ASSOCIATED ROC. Para~~graphs~~ 1521, ~~1522, and~~ 152~~2~~3.

~~If holding is established over the FAF, the FAF shall be a WP, and paragraph 234e(1) applies. The course alignment shall be within 15° of the FAC. If holding is established over the IWP, paragraph 234e(2) applies. The course alignment shall be within 15° of the intermediate course. Where a feeder segment leads to the course reversal, the feeder segment shall terminate at~~

~~the plotted position of the holding WP. See figure 15-15.~~

~~c. **Area**.~~

~~**(1) Length.** The initial approach segment has no standard length. It shall be sufficient to permit any altitude changes required by the procedure and shall not exceed 50 miles unless an operational requirement exists.~~

(2) Width.

(a) Primary area:

1 VOR/DME. See figure 15-18.

a In the 8 NM zone, the area is 4 NM on each side of the centerline.

b In the 4 NM zone, the area is 2 NM on each side of the centerline.

~~b In the 4 NM zone, the area is 2 NM on each side of the centerline.~~

c A 30° splay connects the area boundaries, beginning where the route centerline crosses the 4 NM zone and splaying out as the ATD increases until reaching 4 NM each side of the centerline. In addition:

(1) If the splay cuts across a portion of the WP fix displacement area, retain the width of the wider area and directly connect the wider area boundary with the narrower.

(2) If a short segment transits the 4 NM zone from the 8 NM zone and reenters the 8 NM zone, retain the 8 NM zone.

(3) If the initial approach and succeeding segments lie within the 4 NM zone, the 4 NM zone may be used.

(4) Segments shall not be decreased to 2 NM widths and then increased back to 4 NM widths.

(5) The width of the primary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

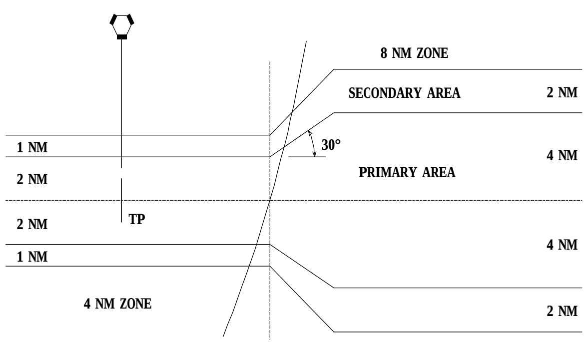


Figure 15-18. VOR/DME BASIC AREA. Para~~graph~~ 1521c(2)(a)1.

2 Non-VOR/DME - 2 miles each side of centerline.

(b) Secondary area:

1 VOR/DME - The area is 1 mile each side of the primary area where the route centerline lies within the 4 NM zone. The area is 2 miles each side of

the primary area where the route centerline lies within the 8 NM zone. The area boundaries are connected by~~the primary area where the route centerline lies within the 8 NM zone. The area boundaries are connected by~~ straight lines abeam the same points where the primary area boundaries connect. The width of the secondary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

2 *Non-VOR/DME* - 1 mile on each side of the primary area.

d. Obstacle Clearance. Paragraph 232c applies. ~~The note in appendix 2, figure 123, 2 NM slant range, does not apply to non-VOR/DME.~~

e. Descent Gradient. Paragraphs 232d and 288a apply.

1522. INTERMEDIATE SEGMENT. The inter-mediate segment begins at the IWP and ends at the FAWP or ATD fix serving as the FAF. For VOR/DME systems, the distance from the reference facility to the IWP shall not exceed 53 miles nor exceed the TPD or ATD values associated with the limits of the 8 NM zone (s~~. S~~ee figure 15-2).

a. Alignment. The course to be flown in the intermediate segment should be the same as the FAC. When this is not practical, the intermediate course shall not differ from the FAC by more than 30° and an FAWP shall be established at the turn WP (s~~. S~~ee figure 15-17).

b. Area.

(1) Length. The intermediate segment shall not be less than 5 miles, nor more than 15 miles in length. If a turn is more than 90° at the IWP, table 3, chapter 2, applies.

(2) Width.

(a) Primary area:

1 VOR/DME - The width of the intermediate primary area shall equal the width of the initial primary area at the IWP. It shall either taper from a point abeam the IWP linearly to ± 2 miles at the FAWP or ATD fix or shall be a constant ± 2 miles, as appropriate. The width at the earliest point the IWP can be received shall equal the width at the plotted position.

2 Non-VOR/DME - 2 miles on each side of centerline.

(b) Secondary area:

1 VOR/DME - The width of the intermediate secondary area shall be equal to the width of the initial secondary area at the IWP and shall either taper from a point abeam the IWP linearly to ± 1 mile at the FAWP or ATD fix or shall be a constant ± 1 mile, as appropriate. The width of the secondary area at the earliest point the IWP can be received shall equal the width at the plotted position.

2 Non-VOR/DME - 1 -mile on each side of the primary area.

c. Obstacle Clearance. Paragraph 242c applies.

d. Descent Gradient. Paragraph 242d applies.

1523. FINAL APPROACH SEGMENT. The final approach segment begins at the FAWP or ATD fix and ends at the MAP. When the FAC is a continuation of the intermediate course, an ATD fix should be used in lieu of a FAWP with additional ATD fixes established, if necessary, as stepdown fixes or the MAP. For VOR/DME systems, the FAWP/ATD fix shall be limited to a TPD of 30 miles or less and must be within the limits of the 4 NM zone shown in figure 15-2.

a. Alignment. The FAC shall be aligned through the RWY or APT WP. For a straight-in approach, the alignment should be with the runway centerline. When the alignment exceeds 15°, straight-in minimums are not authorized. For a circling approach, the FAC should be aligned to the center of the landing area, but may be aligned to any portion of the usable landing surface.

b. Area. The area considered for obstacle clearance starts at the earliest point of the FAWP or ATD fix displacement area, and for straight-in approaches, ends at the latest point of the RWY WP fix displacement area. For circling approaches, the area ends at the latest point of the APT WP fix displacement area.

(1) Length. The optimum length of the final approach segment, measured between plotted fix positions, is 5 miles. The maximum length is 10 miles. The minimum length shall provide adequate distance for an aircraft to make the required descent and to regain course alignment when a turn is required over the FAWP. Table 15-4 shall be used to determine the minimum length of the final approach segment. Fix displacement area overlap restrictions stated in paragraph 1502 apply.

(2) Width.

(a) The final approach primary area is centered on the FAC. It is 2 miles wide on each side of the course at the earliest position the FAWP/ATD fix can be received. See figures 15-15 and 15-16. This width remains constant until the latest point the FAWP/ATD fix can be received. It then tapers to the width of the area of the XTRK fix displacement tolerance at the latest point the RWY WP or APT WP can be received. Fix displacement tolerance dimensions are shown in table 15-2 for VOR/DME systems and in table 15-3 for non-VOR/DME systems.

(b) A secondary area 1 mile wide is established on each side of the primary area (s~~. S~~ee figures 15-15 and 15-16).

c. Obstacle Clearance.

(1) Straight-In. The ROC in the primary area is 250 feet. In the secondary area, the ROC of the primary area is provided at the inner edge, tapering uniformly to zero at the outer edge.

(2) Circling. A minimum of 300 feet of ROC shall be provided in the circling approach area. Paragraph 260b applies.

d. Descent Gradient. Paragraph 252 applies.

e. Using Fixes for Descent. Paragraphs 288a, b, c(3), c(4)(a), and 289 apply.

f. RNAV Descent Angle Information. Paragraph 252 applies.

Figure 15-19 RESERVED

1524.-1529. RESERVED.

SECTION 3. MISSED APPROACH.

1530. GENERAL. For general criteria, refer to chapter 2, section 7. In the secondary areas, no obstacle may penetrate the 12:1 surface extending upward and outward from the 40:1 surface at the edge of the inner boundaries at a right angle to the missed approach course.

1531. MISSED APPROACH SEGMENT. The missed approach segment begins at the MAP and ends at a point designated by the clearance limit. These criteria consider two types of missed approaches. They are identified as RNAV and non-RNAV MAP's and defined as follows:

a. RNAV.

(1) Route. PCG provided by RNAV systems is required throughout the missed approach segment. The length of the segment is measured point-to-point between the respective (plotted position) WP's throughout the missed approach procedure~~MAP~~.

(a) A WP is required at the MAP and at the end of the missed approach procedure. A turn WP may be included in the missed approach.

(b) A straight, turning, or combination straight and turning missed approach procedure~~MAP~~ may be developed. WP's are required for each segment within the ~~MAP~~missed approach procedure.

(c) Turns shall not exceed 120°.

(d) A minimum leg length is required to allow the aircraft's stabilization on course immediately after the MAP. See table 15-6 for minimum distances required for each category of aircraft based on course changes.

(e) For the combination straight and turning missed approach, the distance between the latest point the MAP can be received and the earliest point the turn WP can be received shall be sufficient to contain the length of turn anticipation distance required. This segment shall be aligned within 15° or less of the extended FAC.

(2) Direct. A direct missed approach may be developed to provide a method to allow the pilot to proceed to a WP that is not connected to the MAP by a specified course. PCG is not assumed during the entire missed approach procedure~~MAP~~.

(a) An ATD fix may be specified as the MAP.

(b) A straight, turning, or combination straight and turning missed approach may be developed.

(c) The combination straight and turning ~~MAP~~missed approach procedure shall be a climb from the MAP to a specified altitude. The end of the straight section shall be established by an altitude, and this segment shall be aligned with the FAC. The length of the straight section shall be determined by subtracting the lowest MDA of the procedure from the height of the turning altitude in the missed approach and multiplying by 40. The distance is measured from the latest point the MAP can be received.

(d) Turns may exceed angles of 120°.

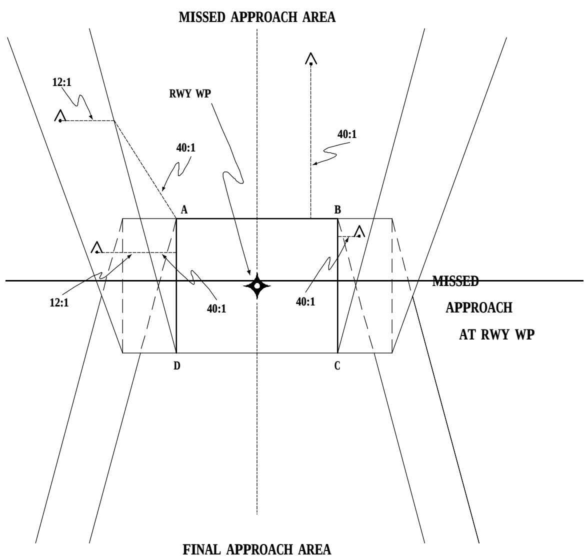
b. Non-RNAV Missed Approach Procedures. Chapter 2, section 7, is applicable for non-RNAV missed approach criteria with the following exceptions: the connection for the missed approach area and the origination points of the 40:1 evaluation obstruction slope at the MAP, and the area for early turns begin at the earliest point the WP or ATD fix can be received. The area connects at the MAP as described in paragraphs 1532, 1533, 1534, and 1535. The tie-backs and evaluations are established and conducted as outlined in this chapter of the RNAV missed approach criteria.

1532~~1532~~. MAP. The MAP shall be located on the FAC and is normally located at the RWY WP or APT WP, as appropriate. It may be designated by an ATD fix defined relative to the distance from the RWY or APT WP. The MAP shall be no further from the FAF than the RWY or APT WP, as appropriate. The area of the MAP ATRK displacement tolerance may overlap the plotted position of the RWY or APT WP. The lateral dimensions for the area of the ATD fix are considered the same as the lateral dimensions of the primary area.

1533. STRAIGHT MISSED APPROACH. Straight missed approach criteria are applied when the missed approach course does not differ more than 15° from the FAC.

a. Area.

(1) When the MAP is at the RWY WP or APT WP, the area starts at the earliest point the MAP can be received and has the same width as the area for the WP displacement tolerance at the RWY WP or APT WP, as appropriate. The secondary areas are 1 mile each side of the primary area at the earliest point the MAP can be received (s~~. S~~ee figure 15-20).



~~**Figure 15-20. STRAIGHT MISSED APPROACH AT**~~

~~**T**~~

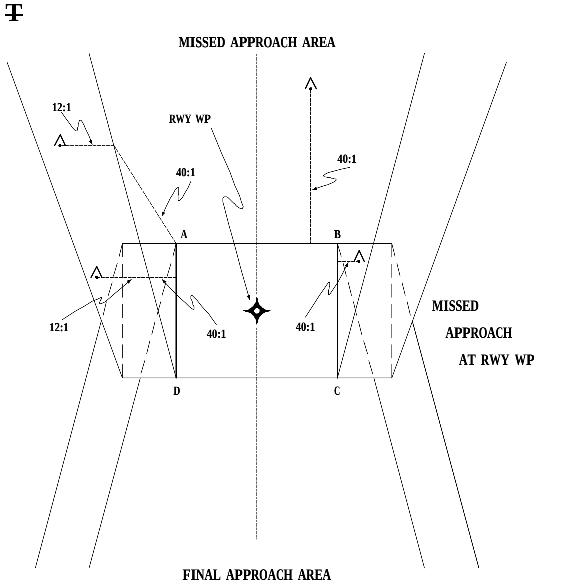


Figure 15-20. STRAIGHT MISSED APPROACH AT THE RWY WP. Para~~graph~~ 1533a(1).

–**(2) When the MAP** is at an ATD fix, the area starts at the earliest point the MAP can be received and has the same width as the final approach primary and secondary areas at that point (s~~. S~~ee figure 15-21).

–**(3) The area expands uniformly** to a width of 6 miles each side of the course line at a point 15 flight-track miles from the plotted position of the MAP. When PCG is provided, the secondary areas splay linearly from a width of 1 mile at the MAP to a width of 2 miles at the end of the 15-mile area. The splay of these areas begins at the earliest point the MAP can be received.

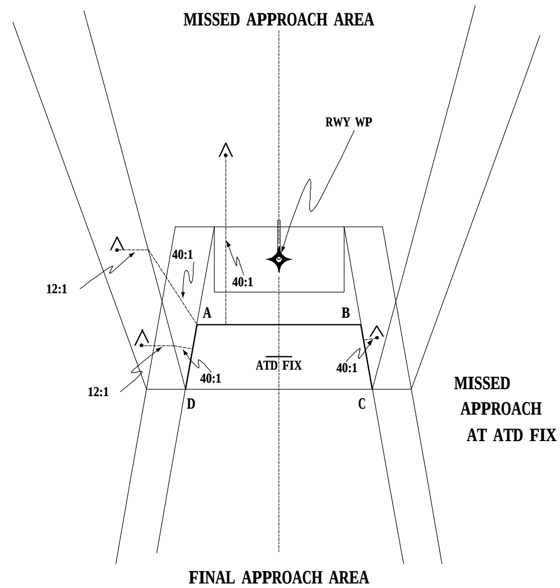


Figure 15-21. STRAIGHT MISSED APPROACH AT AN ATD FIX. Para~~graph~~ 1533a(2).

–**(4) When a turn of 15° or less** causes the outside edge of the primary missed approach boundary to cross inside the lateral dimensions of the fix displacement area of the MAP, that boundary line is then constructed from the corner of the lateral dimension of the area abeam the latest point the MAP can be received. This point is identified as point A at the MAP when represented by a WP or an ATD fix is established as the MAP. See figures 15-22 and 15-23, respectively.

b. Obstacle Clearance. The 40:1 missed approach surface begins at the edge of the area of the WP displacement tolerance or the displacement area of the ATD fix of the MAP identified as the line D-A-B-C in figures 15-20 and 15-21. For the triangular area shaded in figures 15-22 and 15-23 resulting from a skewed course of 15° or less, the 12:1 slope is measured from point A. The obstacle slope is established by measuring the shortest distance from the line D-A-B-C to the obstacle (s~~. S~~ee figures 15-22 and 15-23). The height of the missed approach surface at its beginning slope is determined by subtracting the required final approach obstacle clearance and adjustments specified in paragraph 323 from the MDA~~.~~

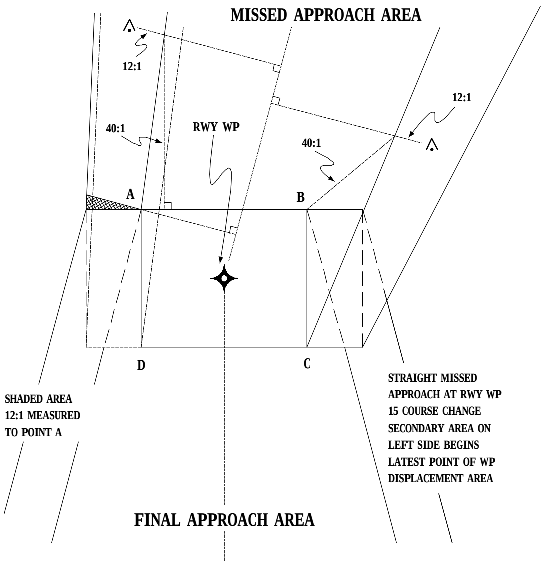


Figure 15-22. CONSTRUCTION OF STRAIGHT MISSED APPROACH WHEN TURNS ≤ 15° CAUSE OUTSIDE BOUNDARY TO CROSS INSIDE MAP FIX DISPLACEMENT TOLERANCE AT RWY WP. Para~~graph~~ 1533a(4).

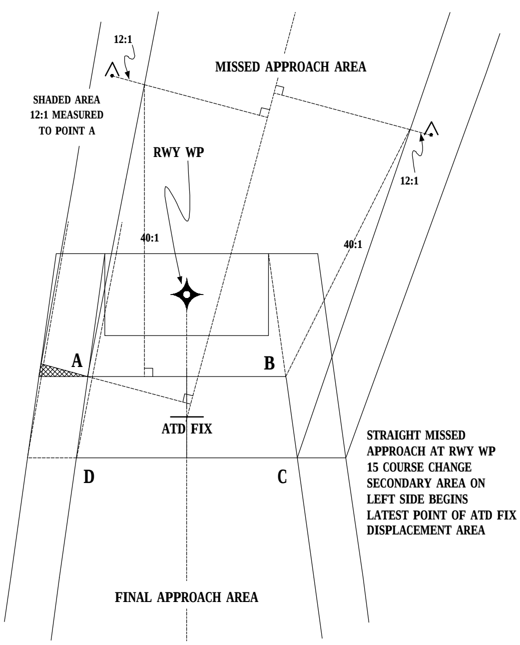


Figure 15-23. CONSTRUCTION OF STRAIGHT MISSED APPROACH WHEN TURNS ≤ 15° CAUSE OUTSIDE BOUNDARY TO CROSS INSIDE MAP FIX DISPLACEMENT TOLERANCE AT AN ATD FIX. Par~~ragraph~~ 1533a(4).

1534. TURNING MISSED APPROACH. Turning missed approach criteria apply whenever the missed approach course differs by more than 15° from the FAC.

a. Area.

(1) Zone 1 begins at a point abeam the latest point the MAP can be received (s. ~~S~~ee figure 15-24).

(2) The turning missed approach area should be constructed by the methods described in paragraph 275, except as follows:

(a) The radii for the outer boundary is constructed from a baseline at the latest point the MAP can be received.

(b) Where the width "d" of the final approach area at the latest point the MAP can be received exceeds the value of the radius of the outer boundary R in table 5, use "wide final approach area at the MAP" construction methodology. If the width "d" is less than or equal to R, use "narrow" methodology (s. ~~S~~ee figure 15-24). Point C_1, for turns of 90° or less, connects to the WP or fix displacement area at point C, which is located at the earliest point the MAP can be received. See figures 15-25 and 15-27. Point C_1, for turns more than 90°, connects to the corner of the WP or fix displacement area at the nonturn side at point D at the earliest point the MAP can be received. See figures 15-26 and 15-28. Point C_1, for turns which expand the missed approach area boundary beyond line E-D-Z, connects to point E (s. ~~S~~ee figure 15-29). Point C_1, for turns which expand the missed approach area boundary beyond line E-Z (parallel to the FAC line), connects to point E_1, a TP of the obstacle boundary arc (s. ~~S~~ee figure 15-30).

b. Obstacle Clearance. The 40:1 obstacle clearance surface begins at the edge of the WP or fix displacement area of the MAP. The height of the missed approach surface over an obstacle in zone 2 is determined by measuring a straight-line distance from the obstacle to the nearest point on the A-B-C line and computing the height based on the 40:1 ratio (s. ~~S~~ee figure 15-26). The height of the missed approach surface in zone 3 is determined by measuring the distance from the obstacle to point C, as shown in figure 15-26, and computing the height based on the 40:1 ratio. The height of the missed approach surface over point C for zone 3 computations is the same height as the MDA, less adjustments specified in paragraph 323.

1535. COMBINATION STRAIGHT AND TURNING MISSED APPROACH.

a. Area.

(1) Section 1 is a portion of the normal straight missed approach area and is constructed as specified in paragraph 15-33 (s. ~~S~~ee figure 15-31). The end of section 1 is based on a turn at a WP, or a climb to an altitude prior to commencing a turn.

(2) RNAV Route Missed Approach Procedure. A turn WP is used to base the length of section 1 for a route RNAV MAP.

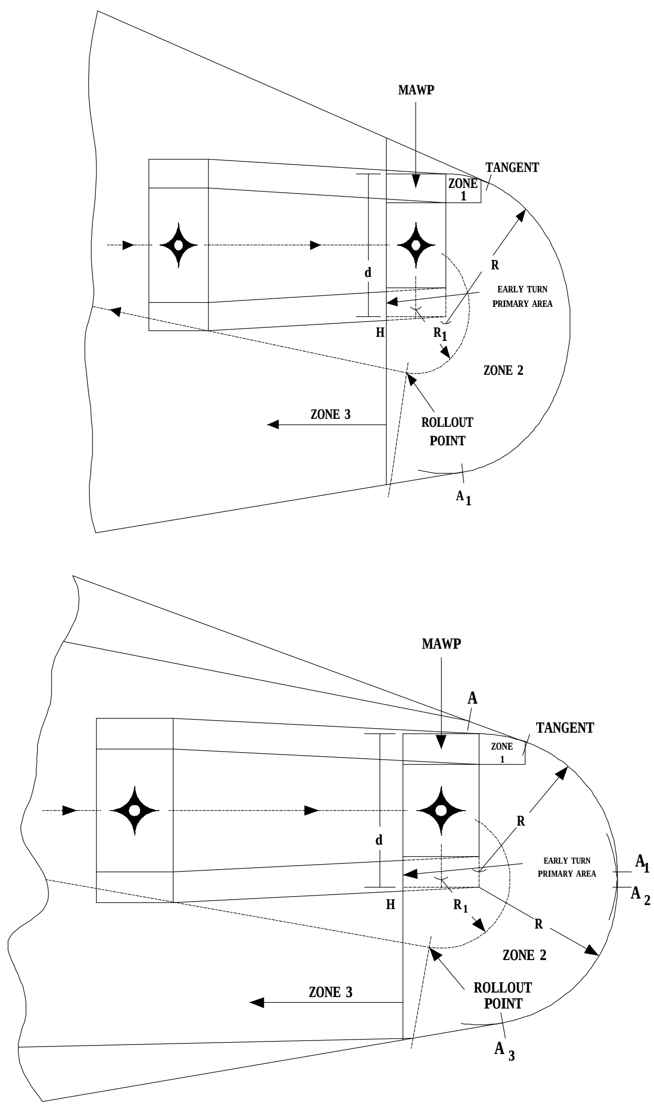


Figure 15-24. WIDE AND NARROW MISSED APPROACH METHODOLOGY.
Para~~graph~~ 1534a(1) ~~1534a(2)~~and (2~~b~~)

(a) Secondary area reductions apply except where the turn exceeds 90°, when the reduction applies only on the nonturning side. See figure 15-32.

(b) For VOR/DME systems, the turn WP shall be limited to a TPD of 30 NM or less and to within the 4 NM zone.

(c) A turn anticipation area shall be constructed at the turn point.

~~(~~(d) Construction.

1 Points F, T_1, T_2, and J represent the end of section 1. For turns 90° or less, point C_1 connects to point J. See figure 15-31. For turns of more than 90°, point C_1 of section 3 connects to point T_2. (s~~S~~ee figure 15-32).

2 The radius for the obstruction boundary is measured from a base line at the latest point the turn WP can be received.

3 The outer boundary line connects tangentially to the outside radius of the boundary arc. Then, the secondary area boundary connects to that line at the point abeam the plotted position of the turn WP. (s~~S~~ee figures 15-31 and 15-32).

(3) RNAV Direct Procedure. For an RNAV direct missed approach, the end of section 1 is based on a climb to altitude, and secondary area reductions are not applied.

(a) The end of section 1 *is established* as described in paragraph 1531a(2)(c). PCG is not assumed, and secondary area obstruction clearance may not be applied. The end of section 1 is represented by line H-T_3 (s~~. S~~ee figure 15-33).

(b) *Construction.*

1 ~~1~~ A base line extension of line G-D-C separates sections 2 and 3. When point C_1 is established prior to the base line, C_1 connects to point C (~~. s~~S~~ee figure 15-33).

2 When C_1 is established beyond the base line, but inside line G-Z, C_1 connects to point G. G-Z is established parallel to the FAC line (s~~. S~~ee figure 15-34).

3 When point C_1 is established beyond an area of line G-Z, C_1 connects to point H (s~~. S~~ee figure 15-35).

4 When point C_1 *is established* beyond an area of line H-Z, C_1 connects to point K, a ~~TP~~tangent point on the boundary arc. H-Z is established paralleled to the FAC line (s~~. S~~ee figure~~s~~ 15-36)~~. and 15-37.~~

b. Obstruction Clearance.

(1) RNAV route missed approach of turns 90° or less.

(a) Obstacles in section 2 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3 (s~~. S~~ee figure 15-31).

(b) Obstacles in section 2b are evaluated based on the shortest distance in the primary area from the obstacle to point T_3 through point J (s~~. S~~ee figure 15-31).

(2) RNAV Route Missed Approach of Turns More than 90°. Obstacles in sections 2 and 3 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3 (s~~. S~~ee figure 15-32).

(3) RNAV Direct Procedure. Obstacles in section 2 are evaluated based on the shortest distance from the obstacle to any point on line G-H-T_3-X. Obstacles in section 3 are evaluated based on shortest distance from the obstacle to point X (s~~. S~~ee figure 15-36).

(4) The height of the missed approach surface over an obstacle in sections 2 or 3 is determined by measuring the shortest distance from the obstacle to the nearest point on the T_2-T_3 line for RNAV routes ~~MAP's~~missed approach procedures and to the nearest point on the H-T_3 line for RNAV direct ~~MAP's~~missed approach procedures. Compute the height of the surface by using the 40:1 ratio from the height of the missed approach obstacle surface at the end of section 1. The height of the obstacle surface at the end of section 1 is determined by computing the 40:1 obstacle surface slope beginning at the height of the missed approach surface measured from the latest point of the MAP (s~~. S~~ee figures 15-32 and 15-36).

(5) The height of the missed approach surface over point X for section 3 computations is the height of MDA less adjustments in paragraph 323a, b, and c, plus a 40:1 rise in section 1 as measured from line A-B to end of section 1.

1536. CLEARANCE LIMIT. The ~~MAP~~missed approach procedure shall specify an appropriate fix as a clearance l~~L~~imit. The fix shall be suitable for holding. For VOR/DME systems, the clearance limit WP's shall meet terminal fix displacement ~~area~~tolerance criteria from table 15-1. For non-VOR/DME systems, clearance limit WP's shall meet en route~~en-route~~ fix displacement tolerance criteria from table 15-3.

1537.-1539. RESERVED.

SECTION 4. APPROACH MINIMUMS.

1540. APPROACH MINIMUMS. Chapter 3, section 3, applies except that table 6A criteria relating minimum visibility to a distance from the station shall be applied as a variation of XTRK fix displacement tolerance of the plotted position of the MAP shown in table 15-5. XTRK values in table 15-2 shall be applied for VOR/DME. An XTRK value of 0.6 NM shall be applied for non-VOR/DME.

1541.-1599. RESERVED.

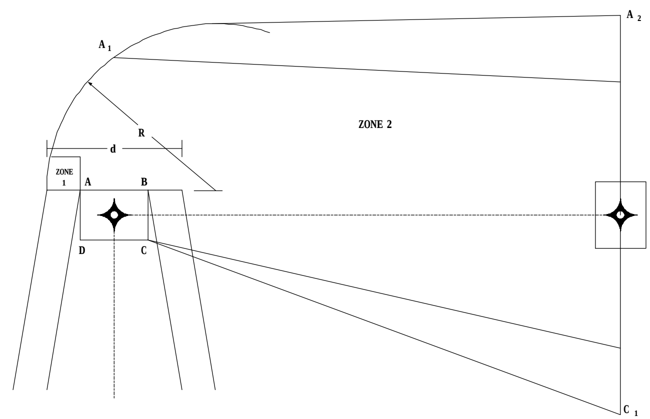


Figure 15-25. RNAV TURNING MISSED APPROACH, 90° OR LESS. Para~~graph~~ 1534a(2)(b).

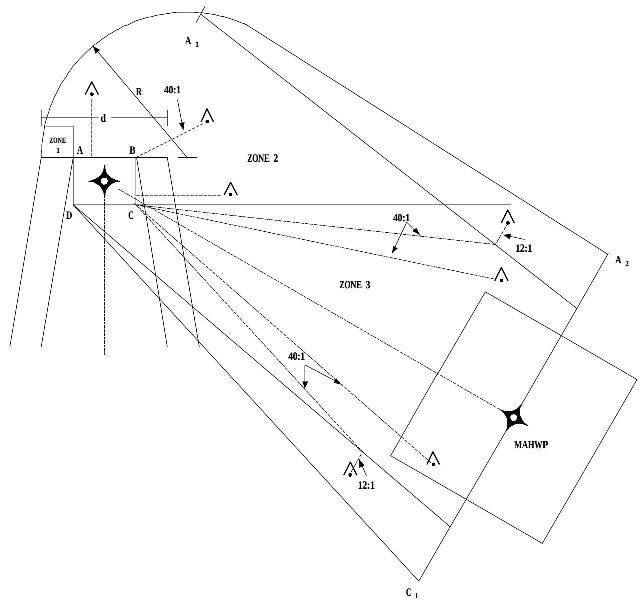


Figure 15-26. RNAV TURNING MISSED APPROACH, MORE THAN 90° UP TO 120°. Para~~graph~~ 1534a(2)(b).

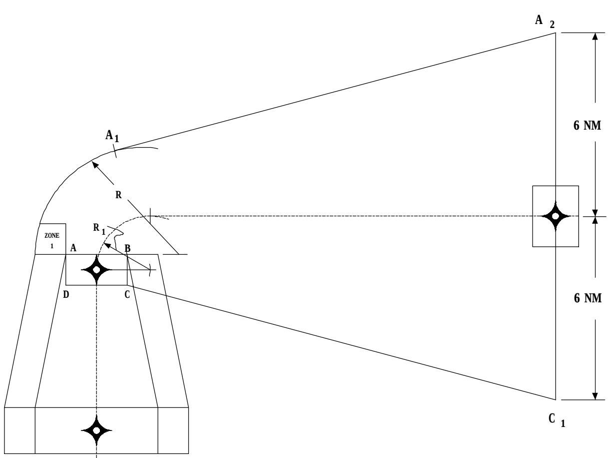


Figure 15-27. DIRECT TURNING MISSED APPROACH, ≤ 90° TIE-BACK POINT C_1 TO POINT C. Para~~graph~~ 1534a(2)(b).

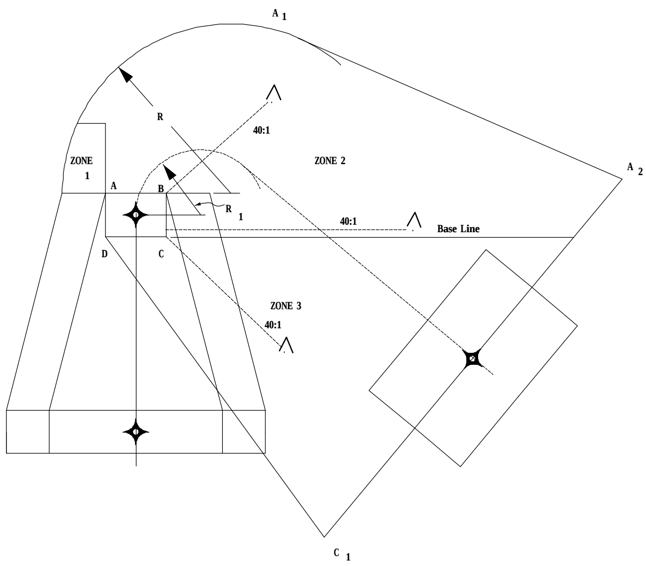
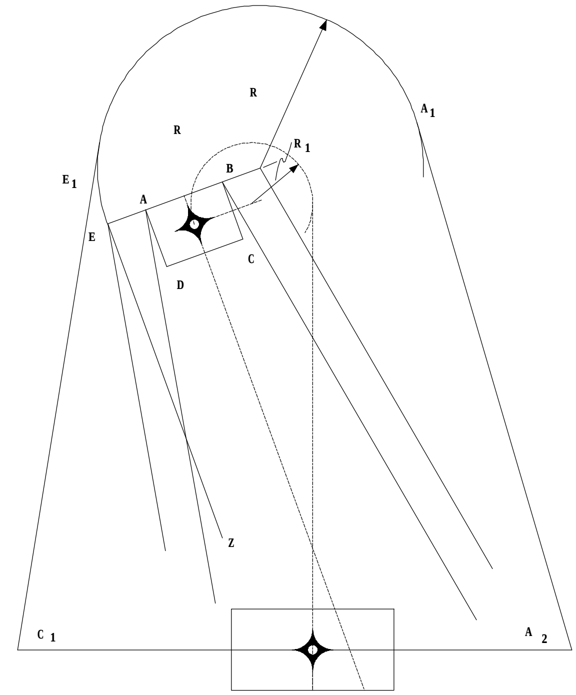
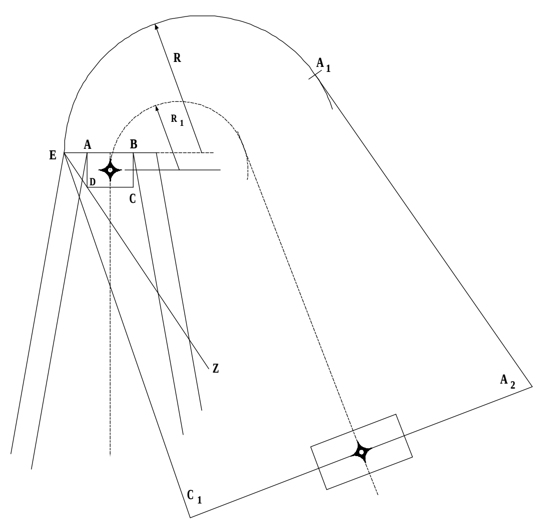


Figure 15-28. DIRECT TURNING MISSED APPROACH, > 90° TIE-BACK POINT C_1 TO POINT D. Para~~graph~~ 1534a(2)(b).



NOTE: Point C_1 connects to E_1 tangent to arc when line C_1-E_1 is outside of line E-Z. E-Z is established parallel to final approach course line.

Figure 15-30. DIRECT TURNING MISSED APPROACH > 180°. Para~~graph~~ 1534a(2)(b).



NOTE: Point C_1 connects to point E when C_1-E is outside of line E-Z. E-Z is established by drawing an extended line through D and E.

Figure 15-29. DIRECT TURNING MISSED APPROACH, > 90°. Para~~graph~~ 1534a(2)(b).

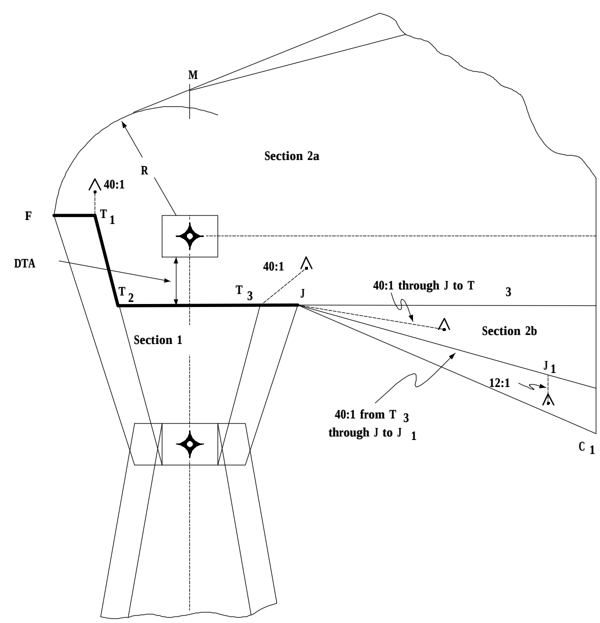


Figure 15-31. RNAV COMBINATION STRAIGHT AND TURNING MISSED APPROACH 90° TURN OR LESS. Para~~graphs~~ 1535a(2) and 1535b(1)(b).

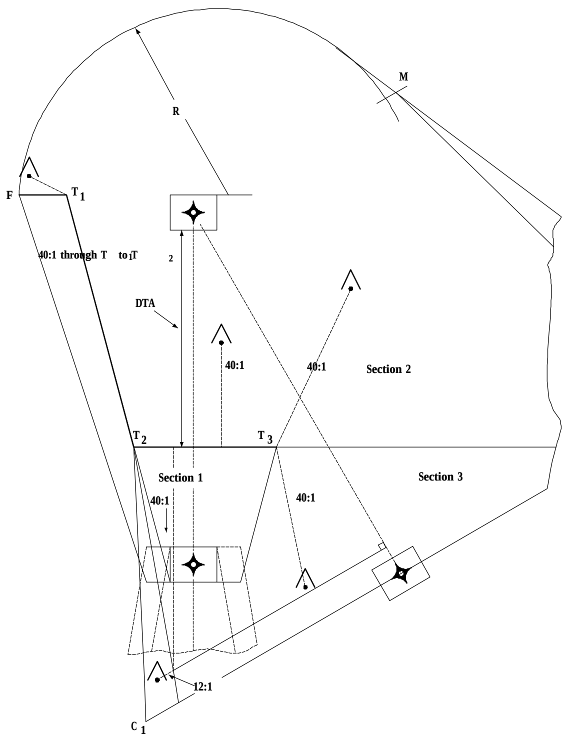


Figure 15-32. RNAV COMBINATION STRAIGHT AND TURNING MISSED APPROACH MORE THAN 90° UP TO 120°. Para~~graph~~ 1535a(2)and b(3).

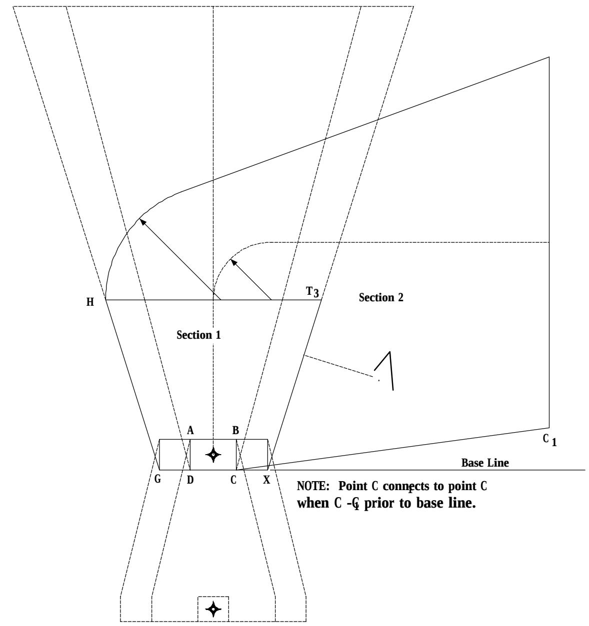


Figure 15-33. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH, C_1 PRIOR TO BASE LINE. Para~~graph~~ 1535a(3)~~)(b)1~~.

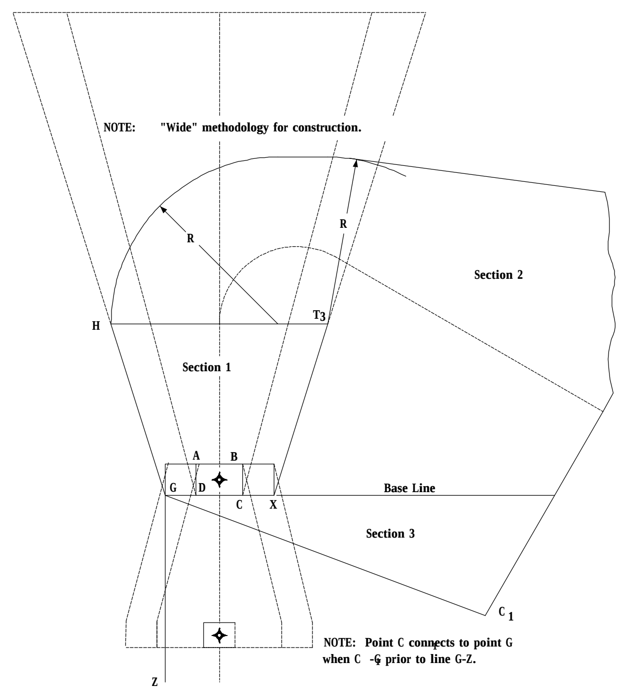


Figure 15-34. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 90°. Para~~graph~~ 1535a(3).

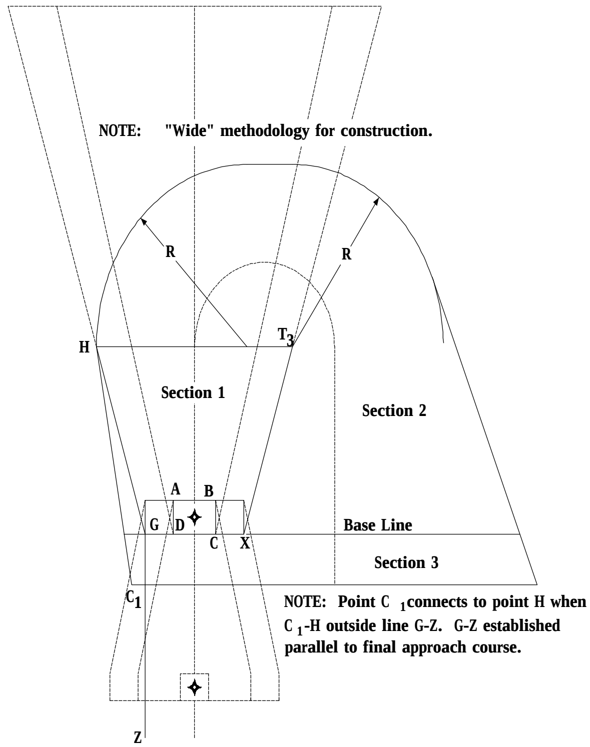


Figure 15-35. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 90°. Para~~graph~~ 1535a(3).

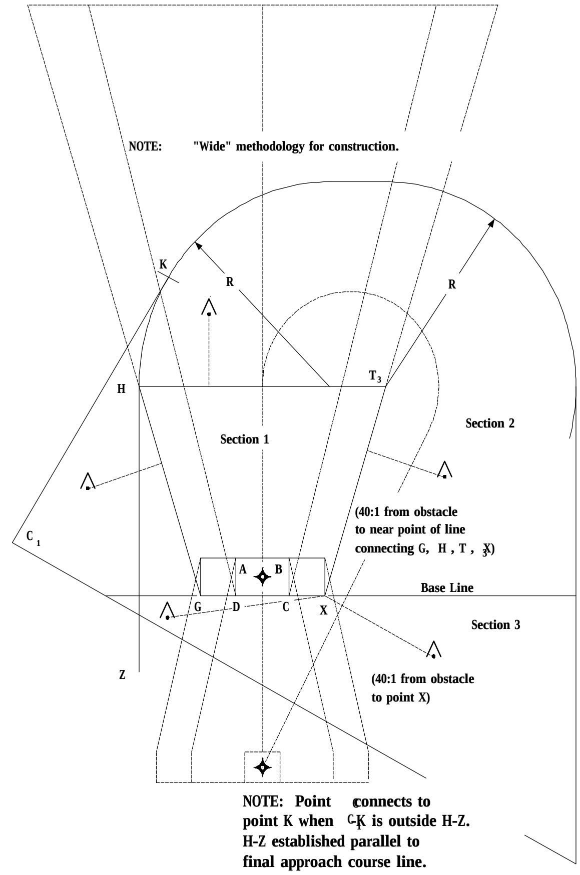


Figure 15-36. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 180§. Par 1535a(3).

~~**Figure 15-36. CLIMB TO ALTITUDE, STRAIGHT AND TURNING MISSED APPROACH > 180§. Paragraph 1535a(3).**~~

Table 15-1. VOR/DME EN ROUTE AND TERMINAL FIX DISPLACEMENT TOLERANCE.

Table 15-2. FINAL/MISSED AREA FIX DISPLACEMENT TOLERANCE.

Table 15-3. NON-VOR/DME FIX DISPLACEMENT TOLERANCE.

Table 15-4. MINIMUM LENGTH OF FINAL APPROACH SEGMENT (NM).

Table 15-5. EFFECT OF XTRK~~CROSSTRACK~~ TOLERANCE ON VISIBILITY MINIMUMS.

	XTRK~~CROSSTRACK~~ TOLERANCE (NM)				
CAT~~EGORY~~	**0.6 - 0.8**	**>0.8 - 1.0**	**>1.0 - 1.2**	**>1.2 - 1.6**	**>1.6**
A	**1**	**1**	**1**	**1**	**1**
B	**1**	**1**	**1**	**1.25**	**1.25**
C	**1**	**1**	**1.25**	**1.5**	**1.5**
D	**1**	**1.25**	**1.5**	**1.75**	**2**
E	**1**	**1.25**	**1.5**	**1.75**	**2**

Table 15-6. MINIMUM LEG LENGTH FROM MAP TO NEXT WP USING RNAV MISSED APPROACH PROCEDURE.

	COURSE CHANGE AT MAP				
CAT~~EGORY~~	**>15° ≤30°**	**≤45°**	**≤60°**	**≤90°**	**≤120°**
	Minimum Leg Length, NM, between MAP and next WP				
A	**3.0**	**4.0**	**5.0**	**5.9**	**6.9**
B	**3.0**	**4.0**	**5.2**	**6.2**	**7.2**
C	**3.0**	**4.2**	**5.5**	**6.5**	**7.6**
D	**3.0**	**4.5**	**6.0**	**7.3**	**8.5**
E	**3.0**	**5.5**	**7.8**	**9.5**	**11.3**

PRECISION

1. COMPUTING GLIDE SLOPE THRES-HOLD CROSSING HEIGHT.

a. Definitions.

(1) Straight Line Extension of GS. The assumed path which the GS would follow if it were a straight line in space from a point over the outer marker to a point of interception with the approach surface baseline.

(2) Threshold Crossing Height (TCH). The height of the straight line extension of the GS above the runway at the threshold.

(3) Established Glide Slope Angle. The angle of the GS as determined by the currently effective commissioning flight check. Flight inspection will provide information concerning the height of the GS at the outer marker, middle marker, or other point of known distance from the runway threshold on final approach.

(4) Runway Point of Intercept (RPI). The point where the extended GS intercepts the runway centerline on the runway surface.

b. Computation Method. The GS threshold crossing height is computed as follows: (See figure 126).

(1) Multiply "D_1" (the distance in feet from the GPI to a point abeam the runway threshold "T") by the tangent of the established GS angle. The result is the TCH.

Figure 126. COMPUTING THRESHOLD CROSSING HEIGHT. Par 1b.

(2) Problem: Find the TCH if:

GS angle is 2 1/2 °. (Tan is .04366).
Distance "D_1" is 1,145 feet.
TCH = D_1 tan GS angle
= 1,145 x .04366
= 50 feet.

c. Glide Slope Antenna Location The GS antenna will be sited in accordance with appropriate civil or military installation standards to provide the desired TCH and GPI.

2. COMPUTATION OF GPI WHEN TCH IS KNOWN. The GPI will be located abeam the glideslope antenna only when the terrain in the vicinity of the runway is perfectly flat. When the terrain slopes significantly between the runway threshold and the GS antenna location, the GPI will not be located abeam the GS antenna. This is because the GPI is the point at which the straight line extension of the glideslope intersects the approach surface base line (ASB). The ASB has the same elevation as the runway threshold. Therefore, the GPI will always be the same distance from the threshold when TCH and GS angles are the same. See figures 129, 129A, 129B, and 129C.

3. APPLICATION OF ILS/PAR OBSTACLE CLEARANCE CRITERIA. Obstacle clearance in the final segment is achieved through application of obstacle clearance surfaces (OCS). See figure 127.

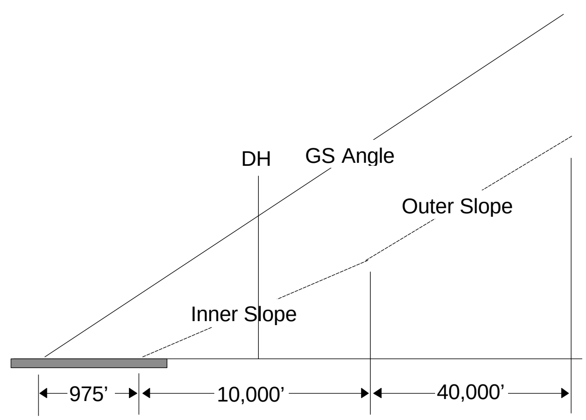


Figure 127. OBSTACLE CLEARANCE SURFACES. Par 3.

a. Definitions.

(1) Ground Point of Intercept (GPI). A point in the vertical plane of the runway centerline at which it is assumed that the straight line extension of the glideslope intercepts the approach surface baseline.

(2) Approach Surface Baseline (ASBL). An imaginary horizontal line at the threshold elevation.

(3) Final Approach OCS.

(a) Inner OCS (OCS_I). An incline plane that originates at the ASBL 975 feet outward from GPI and extends to a point 10,975 feet from GPI.

(b) Outer OCS (OCS_O). An incline plane that originates at the 10,975' point of the inner slope, and extends 40,000 feet.

b. Evaluating the OCS. Compare obstacle height to the appropriate OCS/transitional surface using the formulae below.

(1) Inner OCS (OCS_I). Calculate the height of the OCS_I at any distance D less than 10,975 feet from GPI using the following formula:

$$OCS_I \text{ Height Above THR } = \left[\left(\tan(gs) - 0.02366\right) \times D\right] - 20$$

where: gs = glideslope angle
D = distance from GPI in feet

(2) Outer OCS (OCS_O). Calculate the height of the OCS_O at any distance D greater than or equal to 10,975 feet from GPI using the following formula:

$$OCS_O \text{ Height Above THR } = \left[\left(\tan(gs) - 0.01866\right) \times D\right] - 75$$

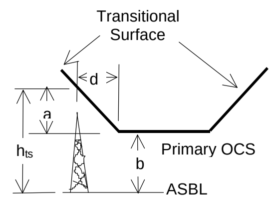
where: gs = glideslope angle
D = distance from GPI in feet

(3) Transitional Surface. Calculate the height of the transitional surface (h_{ts}) at any distance (d) from the edge of the primary area measured perpendicular to the final approach course using the following formulae.

(1) $a = \frac{d}{7}$

(2) $h_{ts} = a + b$

Where a = amount of surface adjustment
b = OCS_I or OCS_O as appropriate



c. Evaluating the Visual Portion of the Final Segment. See figure 128. Apply the criteria in paragraph 251 to determine the effect of obstacles on minimums.

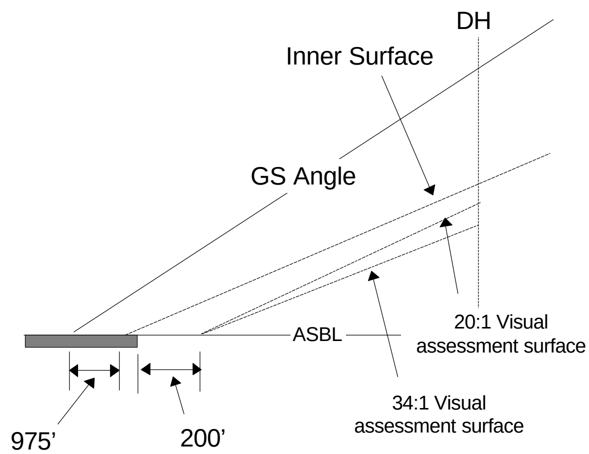


Figure 128. VISUAL SEGMENT SURFACES. Par 3c.

Figure 129. RPI/GPI/TCH COMPUTATIONS FOR ILS WITH RAPIDLY DROPPING TERRAIN. Par 2, Appendix 2.

Figure 129A. RPI/GPI/TCH COMPUTATIONS FOR ILS WITH RELATIVELY SMOOTH TERRAIN, Par 2, Appendix 2.

Figure 129B. RPI/GPI/TCH COMPUTATIONS FOR PRECISION APPROACH RADAR. Par 2, Appendix 2.

Figure 129C. RPI/GPI/TCH COMPUTATIONS FOR USN/USA PRECISION APPROACH RADAR. Par 2, Appendix 2.